RECLAMATION

Managing Water in the West

System Operations Technical Document for the Yakima River Basin

A component of
Yakima River Basin Water Storage Feasibility Study, Washington

Technical Series No. TS-YSS-21

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Upper Columbia Area Office
Yakima, Washington

January 2008

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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PREFACE

The Congress directed the Secretary of the Interior, acting through the Bureau of Reclamation, to conduct a feasibility study of options for additional water storage in the Yakima River basin. Section 214 of the Act of February 20, 2003 (Public Law 108-7), contains this authorization and includes the provision "… with emphasis on the feasibility of storage of Columbia River water in the potential Black Rock Reservoir and the benefit of additional storage to endangered and threatened fish, irrigated agriculture, and municipal water supply."

Reclamation initiated the Yakima River Basin Water Storage Feasibility Study (Storage Study) in May 2003. As guided by the authorization, the purpose of the Storage Study is to identify and examine the viability and acceptability of alternate projects by: (1) diversion of Columbia River water to a potential Black Rock reservoir for further water transfer to irrigation entities in the lower Yakima River basin as an exchange supply, thereby reducing irrigation demand on Yakima River water and improving Yakima Project stored water supplies; and (2) creation of additional water storage within the Yakima River basin. In considering the benefits to be achieved, study objectives are to modify Yakima Project flow management operations to improve the flow regime of the Yakima River system for fisheries, provide a more reliable supply for existing proratable water users, and provide water supply for future municipal demands.

State support for the Storage Study was provided in the 2003 Legislative session. The 2003 budget included appropriations for the Washington State Department of Ecology (Ecology) with the provision that the funds ". . . are provided solely for expenditure under a contract between the department of ecology and the United States bureau of reclamation for the development of plans, engineering, and financing reports and other preconstruction activities associated with the development of water storage projects in the Yakima river basin, consistent with the Yakima river basin water enhancement project, P.L. 103-434. The initial water storage feasibility study shall be for the Black Rock reservoir project." Since that initial legislation, the State of Washington has appropriated additional matching funds.

Storage Study alternatives were identified from previous studies by other entities and Reclamation, appraisal assessments by Reclamation in 2003 through 2006, and public input. Reclamation filed a Notice of Intent and Ecology filed a Determination of Significance to prepare a combined Planning Report and Environmental Impact Statement (PR/EIS) on December 29, 2006. A scoping process, including two public scoping meetings in January 2007 identified several

concepts to be considered in the Draft PR/EIS. Those concepts have been developed into "Joint" and "State" Alternatives.

The Joint Alternatives fall under the congressional authorization and the analyses are being cost-shared by Reclamation and Ecology. The State Alternatives are outside the congressional authorization, but within the authority of the state legislation, and will be analyzed by Ecology only. Analysis of all alternatives will be included in the Draft PR/EIS.

This technical document and others explain the analyses performed to determine how well the alternatives meet the goals of the Storage Study and the impacts of the alternatives on the environment. These documents will address such issues as hydrologic modeling, sediment modeling, temperature modeling, fish habitat modeling, and designs and costs. All technical documents will be referenced in the Draft PR/EIS and available for review.

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Chapter 1 INTRODUCTION

The system operation studies conducted for the Yakima River Basin Water Storage Feasibility Study Draft Planning Report/Environmental Impact Statement (Draft PR/EIS) involve the use of two hydrologic models—the Yakima Project RiverWare (Yak-RW) model and Bonneville Power Administration's computer model (Hyd-Sim). The Yak-RW model is used for all studies involving the reservoir and river operations of the Yakima Project. The Hyd-Sim model is used in regard to the Columbia River operations for estimating the availability of water for withdrawal at Priest Rapids Reservoir for the Black Rock Alternative. This model is also used for assessing the potential effects of such withdrawals on generation at Federal and non-Federal hydropower projects in the mid-to-lower Columbia River.

This System Operations Technical Document includes two parts. Part I (Chapter 2) is a description of the two hydrologic models with major emphasis on the Yak-RW model. Part II (Chapter 3) is a discussion of the operation studies conducted for the Draft PR/EIS and provides information on the criteria used for each operation study and the accomplishments of such operations.

Chapter 2 PART I—DESCRIPTION OF HYDROLOGIC MODELS

2.1 Yakima Project RiverWare Model

The Yak-RW model is a daily time-step reservoir and river operation simulation computer model of the Yakima Project created with the RiverWare software. The software was developed at the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado, in cooperation with the Bureau of Reclamation and the Tennessee Valley Authority.

The RiverWare modeling software uses an object-oriented modeling approach in which objects represent features of the project such as storage reservoirs, stream reaches, diversions, and canals. Each object contains its own physical processes, algorithms and data. For instance, reservoir objects include elevation-volume data, flood-control rule curve information, and outflow data. Objects are interconnected into a "network" which represents the flow of water from one object to another. The network solution is controlled by a set of rules.

2.1.1 Period of Record

The period of record of the Yak-RW model is the 25 water years from 1981 through 2005 (November 1, 1980, through October 31, 2005). This 25-year period includes 18 nonprorated water years (wet and average water supply conditions) and 7 proration years (dry water supply conditions). It also includes the longest dry cycle (1992-1994) and the 2 largest single dry years (2001 and 2005) in the Yakima basin, combined with wet and average water supply conditions. The period of record used is appropriate, as it has a range of wet, dry, and average years and is longer than the minimum 20 years of record hydrologists typically use for a modeling study to capture a range of flows with a standard variability to be statistically valid.

2.1.2 Yakima Project Reservoirs

The network file of the Yak-RW model consists of the five major Yakima Project reservoirs—Keechelus, Kachess, Cle Elum, Bumping, and Rimrock. Table 2.1 provides a summary of these five reservoirs.

Table 2.1. Five major Yakima Project reservoirs

Dam	Reservoir	Location	Construction	Active capacity (acre-feet)	Mean storable[1] annual runoff (acre-feet)
Keechelus	Keechelus Lake	Upper Yakima River	1913-1917	157,800	180,800
Kachess	Kachess Lake	Kachess River, tributary to Upper Yakima River	1910-1912	239,000	200,800
Cle Elum	Cle Elum Lake	Cle Elum River, tributary to Upper Yakima River	1931-1933	436,900	493,800
Bumping Lake	Bumping Lake	Bumping River, tributary to Naches River	1909-1910	33,700	103,000
Tieton	Rimrock Lake	Tieton River, Tributary to Naches River	1917-1925	198,000	321,600
Basin total upstream of Parker				1,065,400	

2.1.3 Yakima River Basin Water Entitlements

The water entitlements of Yakima River Basin diverters are set forth in the *1945 Consent Decree* issued by the District Court of Eastern Washington under Civil Action 21. The *Consent Decree* is a legal document pertaining to water rights and water distribution in the basin.

The *Consent Decree* defines the "total water supply available" (TWSA) as "that amount of water available in any year from natural flow of the Yakima River, and its tributaries, from storage in the various Government reservoirs on the Yakima watershed and from other sources, to supply the contract obligations of the United States to deliver water and to supply claimed rights to the use of water on the Yakima River, and its tributaries, heretofore recognized by the United States."

The *Consent Decree* established procedures by which Reclamation should operate the Yakima Project to meet the water needs of the irrigation entities that predate the Yakima Project (pre-1905 rights) as well as those formed in association with the Yakima Project (post-1905 rights). It states the quantities of water to which most mainstem water users are allowed (maximum monthly and annual diversion limits) and defines a method of prioritization during water-deficient years.

[1] Storable means the inflows reduced for minimum target flows below each reservoir.

The quantities of water in the *Consent Decree* are identified as to nonproratable and proratable entitlements. Nonproratable entitlements are "senior" and held by those with the earliest filed water rights. These entitlements are to be served first from the TWSA. All other water rights are proratable or "junior" (and of equal priority to each other). Any shortages in water-deficient years are shared equally in proportion to the parties' proratable entitlements.

Many entities have both nonproratable and proratable entitlements; however, the Kittitas Division and the Roza Division have only proratable entitlements. Proratable entitlements were secured through water contracts with Reclamation. The contract water supplies are furnished from the five Yakima Project reservoirs and from unappropriated natural and return flows. Such contractors are obligated to repay the Yakima Project storage construction costs and the annual operation and maintenance costs which are allocated to the irrigation purpose.

The entitlements from the *Consent Decree* are used in the Yak-RW model in dry years when the TWSA for irrigation is not sufficient to meet the "total water entitlements."

Table 2.2 is a listing of the water entitlements. Currently, all surface water rights are being adjudicated in the Superior Court of Yakima County, Washington. As part of this adjudication, conditional final orders (CFO) of the Adjudication Court have been issued. In some cases, as part of the CFO, water right settlement agreements have been executed, limiting diversions to a lesser amount than stipulated in the *Consent Decree*. With Yak-RW, the entitlements in the *Consent Decree* are still used for allocating the TWSA between nonproratable and proratable entitlements, but diversion limitations are based on the CFO where appropriate.

Table 2.2. Water entitlements used in the Yakima RiverWare model (acre-feet)

	Total	Annual		April		May		June		July		August		September		October	
		Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro
Anderson Ditch	1,570	1,570	0	140	0	330	0	270	0	260	0	310	0	130	0	130	0
Blue Slough Ditch	4,245	4,245	0	595	0	615	0	595	0	615	0	615	0	595	0	615	0
Boise Cascade	9,259	9,159	100	1,354	15	1,399	15	1,354	15	1,399	15	1,399	15	1,354	15	900	10
Bull Ditch	6,471	6,471	0	1,012	0	1,045	0	1,012	0	1,045	0	1,045	0	1,012	0	300	0
Carmack Parker Ditch	639	639	0	95	0	98	0	95	0	98	0	98	0	95	0	60	0
Cascade Ditch	49,525	49,525	0	8,925	0	9,223	0	8,925	0	8,452	0	5,600	0	5,600	0	2,800	0
Chapman Nelson Ditch	7,641	7,641	0	1,071	0	1,107	0	1,071	0	1,107	0	1,107	0	1,071	0	1,107	0
City of Cle Elum M and I	1,260	1,260	0	180	0	180	0	180	0	180	0	180	0	180	0	180	0
City of Ellensburg M and I	6,000	0	6,000	0	120	0	1,020	0	1,260	0	1,260	0	1,200	0	780	0	360
City of Yakima Irrigation	10,305	8,805	1,500	1,232	225	1,273	262	1,232	342	1,273	218	1,273	218	1,232	165	1,290	70
City of Yakima M and I	9,359	4,859	4,500	681	675	704	788	681	1,028	704	652	704	652	681	495	704	210
Clark Ditch	4,562	4,562	0	714	0	739	0	714	0	739	0	739	0	536	0	381	0
Cobb Upper Ditch	727	727	0	119	0	123	0	119	0	123	0	123	0	60	0	60	0
Congdon Ditch	28,025	23,720	4,305	3,808	690	3,935	713	3,808	690	3,935	713	3,935	713	2,469	446	1,830	340
Ellensburg Mill and Feed Ditch	4,804	4,804	0	702	0	726	0	702	0	726	0	726	0	702	0	520	0
Ellensburg Power Ditch	6,031	6,031	0	928	0	959	0	928	0	959	0	959	0	928	0	370	0
Ellensburg Town Ditch	47,758	47,758	0	7,438	0	7,686	0	7,438	0	7,686	0	7,686	0	5,950	0	3,874	0
Emerick Ditch	687	687	0	119	0	123	0	119	0	123	0	123	0	60	0	20	0
Fogarty Dyer Ditch	3,690	3,690	0	108	0	638	0	717	0	794	0	733	0	480	0	220	0
Foster Naches Ditch	1,510	1,510	0	100	0	280	0	300	0	320	0	270	0	200	0	40	0
Fredricks Hunting Ditch	950	950	0	120	0	130	0	170	0	170	0	180	0	140	0	40	0
Fruitvale Ditch	17,708	17,708	0	2,791	0	2,884	0	2,791	0	2,884	0	2,884	0	2,011	0	1,463	0
Gleed Ditch	22,819	22,819	0	3,618	0	3,738	0	3,618	0	3,738	0	3,738	0	2,475	0	1,894	0
Hubbard Ditch	11,165	11,165	0	1,785	0	1,845	0	1,785	0	1,845	0	1,845	0	1,250	0	810	0
Kelly Lowry Ditch	8,490	8,490	0	1,190	0	1,230	0	1,190	0	1,230	0	1,230	0	1,190	0	1,230	0
Knoke Ditch	1,600	1,600	0	110	0	300	0	350	0	370	0	330	0	120	0	20	0
Kittitas Reclamation District	336,000	0	336,000	0	6,720	0	57,120	0	70,560	0	70,560	0	67,200	0	43,680	0	20,160
Mills and Son Ditch	7,530	7,530	0	1,190	0	1,230	0	1,190	0	1,230	0	1,230	0	1,190	0	270	0
Morrissey Ditch	1,206	1,206	0	178	0	184	0	178	0	184	0	184	0	178	0	120	0
Moxee Irrigation District	5,205	4,245	960	595	86	615	144	595	182	615	182	615	182	595	125	615	59
Naches Cowiche Ditch	15,096	15,096	0	2,380	0	2,460	0	2,380	0	2,460	0	2,460	0	1,726	0	1,230	0
Naches Selah Irrigation District	54,144	49,658	4,486	7,080	674	7,263	811	7,080	901	7,321	1,050	7,321	1,050	6,884	0	6,709	0

Table 2-2. Water Entitlements Used in the Yakima RiverWare Model (acre-feet) (con't)

	Total	Annual		April		May		June		July		August		September		October	
		Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro	Non-Pro	Pro
Nile Valley Ditch	4,350	4,350	0	230	0	470	0	730	0	980	0	970	0	670	0	300	0
Oconner Ditch	3,100	3,100	0	0	0	330	0	660	0	830	0	740	0	450	0	90	0
Old Union Ditch	17,675	17,675	0	2,813	0	2,907	0	2,813	0	2,907	0	2,907	0	1,875	0	1,453	0
Wapato Irrigation Project	655,613	305,613	350,000	42,843	31,500	44,271	73,500	42,843	70,000	44,271	80,500	44,271	73,500	42,843	21,000	44,271	0
Richartz Ditch	6,364	6,364	0	892	0	922	0	892	0	922	0	922	0	892	0	922	0
Roza Irrigation District	375,000	0	375,000	0	37,500	0	56,250	0	71,250	0	71,250	0	71,250	0	45,000	0	22,500
Selah Moxee Irrigation District	31,774	27,493	4,281	4,284	427	4,427	685	4,284	814	4,427	898	4,427	857	3,320	600	2,324	0
Sinclair Ditch	786	786	0	119	0	123	0	119	0	123	0	123	0	119	0	60	0
South Naches Ditch	22,946	22,946	0	3,689	0	3,812	0	3,689	0	3,812	0	3,812	0	3,272	0	860	0
Stanfield Ditch	1,600	1,600	0	30	0	280	0	370	0	430	0	330	0	100	0	60	0
Stevens Ditch	1,950	1,950	0	60	0	410	0	350	0	410	0	320	0	290	0	110	0
Sunnyside Division	458,520	315,836	142,684	47,070	7,840	48,636	27,874	47,066	31,234	48,637	31,443	48,637	31,443	47,070	12,850	28,720	0
Taylor Ditch	8,000	8,000	0	1,190	0	1,230	0	1,190	0	1,230	0	1,230	0	1,190	0	740	0
Tenant Ditch	1,570	1,570	0	110	0	210	0	220	0	410	0	320	0	230	0	70	0
Yakima-Tieton Irrigation District	114,049	75,865	38,181	0	6,000	15,372	6,641	14,876	7,141	15,372	6,641	15,372	6,641	14,876	5,117	0	0
Tjossem Ditch	4,771	4,771	0	756	0	781	0	756	0	781	0	781	0	756	0	160	0
Vertrees 1 Ditch	2,164	2,164	0	181	0	407	0	400	0	551	0	428	0	177	0	20	0
Vertrees 2 Ditch	704	704	0	107	0	111	0	107	0	111	0	111	0	107	0	50	0
Wapatox Ditch	20,230	20,230	0	3,064	0	3,167	0	3,064	0	3,167	0	3,167	0	3,064	0	1,537	0
Westside Irrigation Company	39,328	31,128	8,200	4,760	550	4,919	1,550	4,760	1,500	4,919	1,550	4,919	1,550	4,760	1,500	2,091	0
Woldale Ditch	12,973	12,973	0	2,023	0	2,091	0	2,023	0	2,091	0	2,091	0	1,547	0	1,107	0
Younger Ditch	3,010	3,010	0	40	0	440	0	780	0	790	0	740	0	180	0	40	0
Union Gap Irrigation District	25,303	20,697	4,606	3,273	571	3,382	734	3,273	785	3,382	812	3,382	872	2,279	582	1,726	250
Total	2,497,761	1,216,958	1,280,803														

2.1.4 Yakima Project Diversions

The network file of the Yak-RW model includes 60 major and minor river diversions and canal systems. River diversions represented in the model include associated canal losses, on-farm losses, and return flows with each diversion. The procedure for determining the daily diversion of each of the 60 diverters used in the Yak-RW model is discussed below.

2.1.4.1 Nonprorated Diversions of Five Irrigation Divisions and Two Major Canals Upstream of Parker

The nonprorated daily irrigation diversion for each of the five Yakima Project divisions upstream of Parker (Kittitas, Roza, Tieton, Wapato, and Sunnyside) and for two major canals (Westside Irrigation Company and Naches-Selah Irrigation District) were determined by using the daily measured diversions for the 7 nonprorated water years of 1991 and 1995-2000.[2] An irrigation season daily demand curve of flow (cfs) vs. day was then developed from these 7 years of data. Figure 2.1 is the nonprorated water year irrigation demand curve for the five Yakima Project divisions and the two major canals. Diversions made from March unregulated waters are included in this figure.

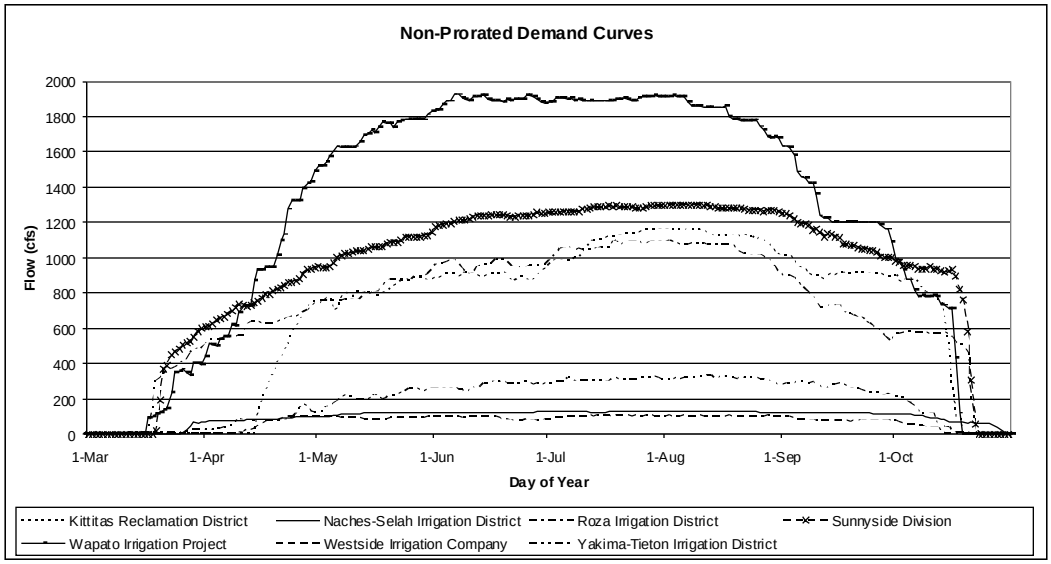

Figure 2.1. Nonprorated Water Year Irrigation Daily Demand Curves

[2] These 7 nonprorated years represent full water supply and diversions.

Table 2.3 shows the computed nonprorated April-October diversions based on Figure 2.1 and the entitlements for the five Yakima Project divisions upstream of Parker and for the Westside Irrigation Company and the Naches-Selah Irrigation District. The entitlements represent the April-October irrigation season entitlements summarized in Table 2.2.

2.1.4.2 Nonprorated Diversions of Other Irrigation and M&I Upstream of Parker

For the 49 other diverters, the nonprorated daily diversion of each diverter was computed by: (1) extracting the daily flow from the irrigation demand curve of the Westside Irrigation Company for Yakima River diverters upstream of Roza Dam and the Naches-Selah Irrigation District for Yakima River downstream from Roza Dam, and for Naches River diverters; and (2) multiplying this daily flow figure by the ratio of the specific diverter's water entitlement to the water entitlement of either the Westside Canal Company or the Naches-Selah Irrigation District. This procedure is illustrated below:

$$\text{cfs from demand curve of representative entity} \times \frac{\text{water right of diverter}}{\text{water right of representative entity}}$$

2.1.4.3 Prorated Diversions Upstream of Parker

Beginning in April during prorated water years, the diversions are limited to the nonprorated demand curve adjusted by the Natural Runoff Proportion (NRP) or entitlements adjusted by the proration level.[3] However, at no time between April and September are diversions set greater than the nonproration daily diversions shown in Figure 2.1. Further, in years of proration, October diversions at no time are set greater than the October irrigation demand curve shown in Figure 2.2.

[3] Natural Runoff Proportion attempts to maximize the use of natural runoff (the unregulated runoff below storage reservoirs) and return flows and, at the same time, minimize storage releases to meet demands. The major water users upstream of Parker voluntarily agree to share natural runoff and return flow supply proportionally based on their water rights. If reservoir releases are called for prior to storage control and formal prorationing, they will be deducted from the requesting entity's water bucket when prorationing formally begins.

Table 2.3. Entitlements and Diversions

Entity	Entitlements			Limitation on diversion from adjudication of Water Right Settlement	Average April-October nonprorated year diversion
	Nonproratable	Proratable	Total		
Kittitas	- - - -	336,000	336,000	331,000[4]	334,100
Roza	- - - -	375,000	375,000[5]	- - - -	339,700
Yakima-Tieton	75,865	38,181	114,049	96,611[6]	92.200
CFO	(75,865)	(31,333)	(107,198)[7]		
Stipulation & Settlement Agreement				101,400[8]	
Wapato	305,613	350,000	655,613	- - - -	604,800
Sunnyside	315,836	142,684	458,520	435,422	435,422
CFO	(315,836)	(119,586)	(435,422)[9]		
Westside	31,128	8,200	39,328	- - - -	33,100
CFO	(25,767.5)	(8,200)	(33,967.5)[10]	33,967.5	
Naches-Selah	49,658	4,486	54,144	- - - -	47,500
CFO	(46,254)	(4,486)	(50,740)[11]	50,740	

[4] CFO dated June 1, 1994. Settlement Agreement completed August 6, 2006, provides that 6,000 acre-feet of the maximum that can be diverted may be used for Yakima River mainstem instream flow purposes in Big Creek and Little Creeks.

[5] CFO dated June 1, 1994.

[6] This is the limitation on the largest claim; two smaller claims were also approved, see footnote 5.

[7] CFO dated September 14, 1995, and CFO on Remand dated May 10, 2001, excludes 75,865 acre-feet from proration.

[8] Stipulation filed December 22, 2000, and Settlement Agreement of April 2001, provide an aggregate total annual diversion limitation of 101,400 acre-feet as follows: 3,881 acre-feet (11/1–3/31); 96,611 acre-feet (4/1–10/31); and 908 acre-feet (3/1–7/31), and states, "Regardless of whether the amounts of water ultimately decreed in Acquavella are greater than the above amounts, YTID covenants to and does limit and restrict its diversions and rights of appropriation under federal and state law to the above amounts . . . "

[9] CFO dated August 14, 2003; Amended Stipulation dated July 31, 2003; total annual quantity – 435,422 acre-feet.

[10] CFO dated August 11, 2005; Stipulation dated June 9, 2005; Settlement Agreement dated May 20, 2005.

[11] CFO dated September 1, 1996; Stipulation dated July 12, 2005 established "shall not exceed" amount of 50,740 acre-feet.

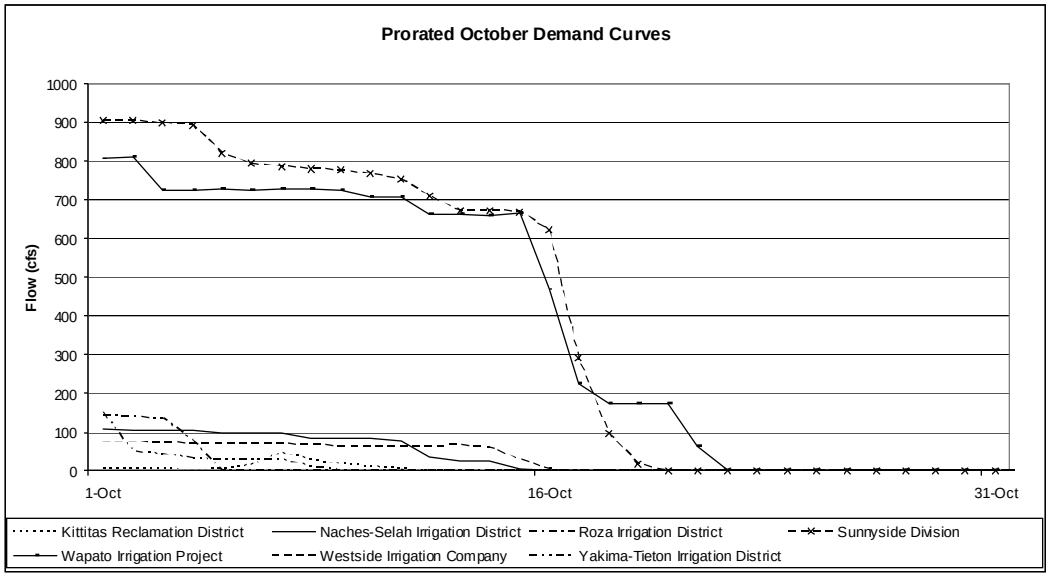

Figure 2.2. Prorated Water Year October Irrigation Daily Demand Curves

2.1.4.4 Irrigation Diversions Downstream from Parker

There are four diversions downstream from Parker—Kennewick Irrigation District (KID), Columbia Irrigation District (CID), Kiona Irrigation District, and Richland Irrigation District.

Historic daily diversions were used for KID; CID is estimated as 70% of the historic KID diversion; and Kiona is estimated as 10% of the historic KID diversion. Richland diversions were simulated as shown in Table 2.4.

Table 2.4. Richland Irrigation District annual diversion curve (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
46	26	27	23	22	18	17	25	33	46	51	40

2.1.4.5 Proration

In actual Yakima Project operations, prorationing begins on the date of storage control or earlier, as determined by Reclamation's Yakima Field Office Manager. Formal prorationing is announced at that time by Reclamation, and updated thereafter monthly, biweekly, or weekly as needed. An illustration of prorationing is shown in Table 2.5 using water year 1994.

Table 2.5. Prorationing example—water year 1994

Start of proration period	Storage control date	Apr	May	Jun	Jul	Aug	Sep	End of proration period
May 1	June 1	NRP	47% - 35%	34%	39%	39%	37%	Sept 30

In the above illustration, the proratable water supply received in July was 39 percent of the entities' July water entitlement; the proratable water supply received in September was 37 percent of the September entitlement. The water year proration level reported by the Yakima Project reflects the end of season (September 30) proration—in this instance, 37 percent. Because of this process, in a year of proration, comparing the monthly diversions and the monthly water entitlements for the proration period (start of proration to end of proration period) will generally not result in the same proration level as reported September 30. Likewise, a comparison of total water year diversions to the total entitlements will be different.

While the Yak-RW model computes daily proration values, the value chosen to be reported in this report for the water year is September 30. This is consistent with Yakima Project annual reporting. To illustrate the model's output and what the proration level does and does not show, information for the Roza Irrigation District (RID) for water year 1994 from the simulated Yakima Project current operation over the 25-year historical period of record (1981-2005) is shown in Table 2.6.

Table 2.6. Roza Irrigation District's simulated current water supply, Yak-RW model for water year 1994

	Apr	May	Jun	Jul	Aug	Sep	Total
	(acre-feet)						
Entitlements	37,500	56,250	71,250	71,250	71,250	45,000	352,500
Diversions	36,300	21,630	21,850	21,860	21,550	13,080	136,270
	Proration Level (percent)						
Monthly	NRP	38	31	31	31	29	
Total Supply[12]							38
Proration Period[13]	NA						32
September 30	NA	NA	NA	NA	NA		29

[12] Total April-September proratable supply provided divided by the April-September entitlements.
[13] Total May-September proratable water supply provided divided by the May-September entitlement.

In the operation studies conducted for the Storage Study, a 70-percent irrigation water supply goal is used for all the alternatives. This goal is to provide a not less than 70-percent water supply for each month of the dry year.

2.1.4.6 Nonirrigation Diversions

There are three nonirrigation diversions simulated by Yak-RW—Diversions associated with Kittitas Reclamation District's (KRD) 1146 Wasteway, Roza Powerplant diversions, and Chandler Power Plant diversions.

KRD's 1146 Wasteway routes water around Easton between September 1 and October 21 to hold flows in the Easton reach at not more than 220 cfs when possible. The 1146 Wasteway is limited to a maximum flow of 480 cfs.

The Roza Powerplant was operated daily except between October 20 and November 20, when it was assumed shut down for maintenance. The maximum flow allowed through the powerplant was 1075 cfs. The maximum combined flow allowed in the Roza canal for power and irrigation flows was 1,900 cfs. The powerplant was only allowed to operate if flows passing Roza Dam exceeded 400 cfs.

Chandler Power Plant diversions were simulated as the smaller of historic daily diversions or simulated flows above Prosser Dam less the Title XII targets.

2.1.5 Instream Target Flows

The instream target flows used in the Yak-RW model are shown in Table 2.7 and Table 2.8. These include:

- The minimum target flows downstream from the five Yakima Project dams.
- The target flow in the Naches River at Naches at the gaging station near the Yakima River confluence at Naches River Mile (RM) 0.6.
- The Title XII target flows at the Yakima River gaging station at Parker immediately downstream from Sunnyside Diversion Dam which are stipulated in the Act of October 31, 1994.

Table 2.7. Minimum target flows used by the Yak-RW model

River location	Daily flows (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tieton Dam	45	45	45	45	45	45	45	45	45	45	45	45
Bumping Dam	130	130	130	130	130	130	130	130	130	130	130	130
Keechelus Dam	80	80	80	80	80	80	80	80	100	100	80	80
Kachess Dam	15	15	15	15	15	15	15	15	15	15	15	15
Cle Elum Dam	220	220	220	220	220	220	220	220	220	220	220	220
Easton Diversion Dam	220	220	220	220	220	220	220	220	220	220	220	220
Naches River at Naches	Minimum of natural flow right or 450 cfs											
Parker				Title XII flows								

Table 2.8. Parker instream target flows used by the Yak-RW model

Total water supply estimate (maf)				Parker flow (cfs)
Apr thru Sep	May thru Sep	Jun thru Sep	Jul thru Sep	
3.2	2.9	2.4	1.9	600
2.9	2.65	2.2	1.7	500
2.65	2.4	2.0	1.5	400
Less than above				300

2.1.6 Total Water Supply Available

The TWSA estimate is a basic component of the Yak-RW model. Every year, Reclamation prepares forecasts of the TWSA in the Yakima River basin upstream of Parker for the period April 1 through September 30. Each year's first official forecast is made beginning in March. The TWSA estimate is updated each month through July. (In a dry year, forecasts may continue through to the end of the irrigation season.) These forecasts are the basis for determining the adequacy of the TWSA to meet irrigation water entitlements and for deciding the amount of proration, if any, which may be necessary.

Simply put, April 1 to September 30 TWSA is equal to:

- The forecasted runoff volume for April 1 through September 30,
- Plus the reservoir storage contents at the end of day on March 31,
- Plus an estimate of usable return flow volume upstream of Parker for April 1 through September 30.

The sum of the above three items, or the TWSA, is used to determine the instream flow targets for the year in accordance with Title XII operating criteria.

The "water supply available for irrigation" (WSAI) is equal to:

- The TWSA,
- Minus the estimated September 30 reservoir contents (desired carryover),
- Minus the flow passing Parker – undiverted unregulated flow, operational spills, and Title XII quantified target flows.

When the nonproratable irrigation entitlement is subtracted from the total WSAI, the remaining volume is the water supply available to meet proratable entitlements. If this amount is less than 100% of the proratable entitlement, prorationing is necessary.

Figure 2.3 illustrates the TWSA components and its distribution.

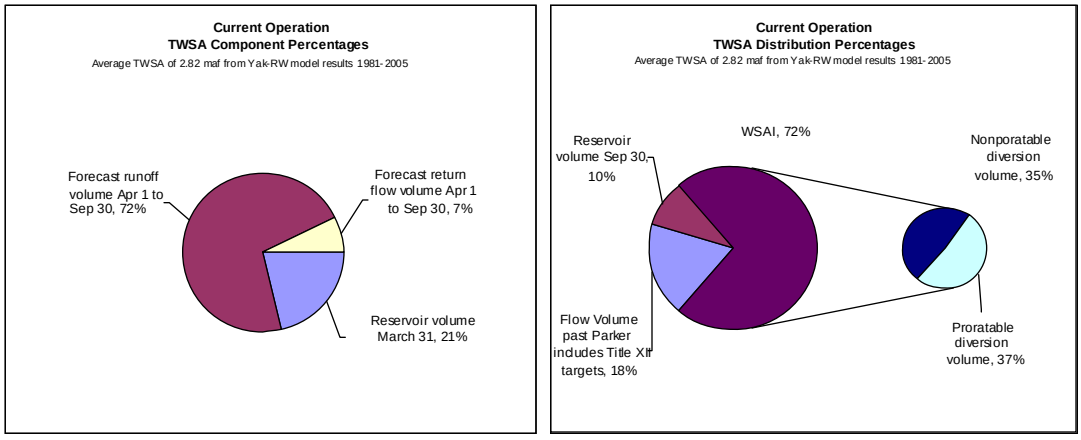

Figure 2.3. TWSA components and distribution

2.1.7 How the Model Works (Operating Rules)

The Yak-RW model is based on current Yakima Project operations (ruleset) described in the *Draft Interim Comprehensive Basin Operation Plan, Chapter 5: Current Project Operations*, dated May 12, 2002 (Reclamation, 2002). Items such as the current minimum target flows downstream from existing dams (Table 2.7), the "flip-flop" operation, (see section 3.1 for a description of "flip-flop") and the Title XII instream target flow operations (Table 2.8), began at different times during the period of record but are included in the model for the

entire 25 years. Because of this, as well as adjustments made during actual "hands-on operation," there will be differences in the modeled results such as proration levels when compared to the historic information.

The primary ruleset components and how they are applied in the model follow:

1. The TWSA upstream of Parker is computed each day for the April 1-through-September 30 period. The daily TWSA is estimated by totaling calibrated inflows for the remaining period, modeled reservoir contents from the previous day, and estimated irrigation return flows for the remaining period. The TWSA is used to set daily instream target flows at Parker in accordance with Title XII and to determine the WSAI. WSAI is calculated by reducing from TWSA the minimum October 1 storage desired (76,000 acre-feet) and the estimated volume passing Parker for the period remaining. If proration is necessary, the irrigation proration level is calculated as the water supply available for irrigation (WSAI), less the April-through-September nonproratable entitlements remaining, divided by the April-through-September proratable entitlements remaining.

   Prior to using the proration level to limit irrigation diversions, an estimate of daily natural runoff to meet irrigation demands is made. The natural runoff is adjusted for Parker target flows. If the day's natural runoff is large enough to meet up to 75 percent of the irrigation demands, then diversions are limited to this amount. However, once 75 percent of the demands cannot be met from the natural runoff, proration is declared and the proration level is used to limit the demands. The September 30 proration level is used during October.

   At this point, the current day's irrigation demands and the Parker instream target flows are known.

2. Operating guidelines for each reservoir are determined based on the flood control system rule curve and a targeted September 1 reservoir volume. The winter and spring operating guidelines (November 1 through June 30) are based on the "Flood Control Rule Curve," dated February 25, 1974, (Reclamation, 1974) which is premised on attempting to maintain flows at Parker to no more than 12,000 cfs during the nonirrigation season, and 17,200 cfs during the irrigation season, including diversions of 5,200 cfs upstream of Parker. These rule curves may be adjusted to attempt to maximize total system storage on or near June 30.

   After determining the required system storage space from the flood control rule curve, the space requirement within each reservoir is distributed as

follows: Keechelus, 13 percent; Kachess, 12 percent; Cle Elum, 42 percent; Bumping, 13 percent; and Rimrock, 20 percent.

Once the system is on storage control (historically about June 24), operating guidelines are used to draft from the reservoirs.[14] The goal of these guidelines is to maximize storage carryover by first using water from the reservoirs with the highest refill ratios, and to allow for flip-flop operations, which are achieved by targeting September 1 elevations at each reservoir. The basic concept is to call on Cle Elum and Keechelus Lakes to meet Yakima River irrigation demands prior to September 1. After September 1, Kachess Reservoir is used to meet Yakima River irrigation demands upstream of the Naches River confluence, and Rimrock Reservoir is used to meet Yakima River irrigation demands downstream from the Naches River confluence.

At this point, the day's desired reservoir elevations are known.

Once the Parker instream target flows, irrigation diversion allocations, and desired reservoir elevations are determined, releases from each reservoir can be calculated. The volume to be released from a particular reservoir each day is subject to minimum flow requirements below project dam(s), desired reservoir elevations, maximum channel capacities, downstream irrigation demands and the point(s) of diversion, instream target flows on the Naches River, and instream target flows at Parker. Minimum flow requirements and instream target flows are shown in Table 2.7; Parker target flows are shown in Table 2.8.

At this point, water releases from each reservoir are known.

3. Lastly, once releases have been made at each reservoir, river reach flows can be determined. The model is able to control the operation of KRD's 1146 Wasteway to bypass fall reservoir releases around the Easton Reach (a part of the mini flip-flop operation) and for operation of the Roza and Chandler Powerplants.

[14] The system is on storage control when the Yakima River flow at Parker can be controlled to the Title XII target flows only by using supplemental storage releases. Once unregulated streamflow fails to meet diversion demand and target flows downstream, reservoirs release water to meet these demands, depleting reservoir storage.

2.2 Columbia River Hyd-Sim Computer Model

The Bonneville Power Administration's (BPA) computer Hyd-Sim model includes all significant United States Federal and non-Federal dams and the major Canadian projects on the mainstem Columbia River and its major tributaries. The Hyd-Sim model is accepted widely as accurately simulating current operation of the Columbia River system. Input to the Hyd-Sim model includes the current Federal Columbia River Power System (FCRPS) operating requirements of each project and historic hydrologic flow conditions. The data set of runoff from water years 1929-1978 has recently been updated by BPA to water year 1998. It has been further extended by Reclamation through water year 2005 to provide a compatible 25-year period of record consistent with the Yak-RW model.[15]

Given a set of operating parameters of each project, BPA can determine the Columbia River operation that best minimizes impacts on each project and optimizes use of water resources. Hyd-Sim model output includes information such as inflow, outflow, end-of-month reservoir elevations, power generation at each project, and monthly average flows at different target points on the system.

The Hyd-Sim model splits the average monthly flows for the months of April and August, so the first 15 days are separate from the remaining days of these two months. This is because April and August are dynamic months in which flows can change dramatically. The April split represents the fact that that target flows start in mid-April. The August split represents the higher flows that typically occur during the first half of August and drop off during the last half of the month. Splitting the August water supply provides a more realistic hydrograph. The Hyd-Sim model considers the remaining months as ten single monthly averages for each year.

[15] The water year used in the Hyd-Sim model is a "power water year" that begins in August and ends in July each year. The Yak-RW model uses an "irrigation water year" that runs from November through October. The output from the Hyd-Sim model is shown to correspond to the "irrigation water year" used by Reclamation.

Chapter 3 PART II—DESCRIPTION OF OPERATION STUDIES

Operation studies were conducted using Yak-RW to assess the extent the Storage Study's water supply goals could be met when each alternative is integrated with the existing Yakima Project. Output from these operation studies are the basis for estimating the benefits of the primary Storage Study purposes of improving anadromous fishery, improved dry-year irrigation water supply, and meeting future municipal water supply; and secondary purposes such as resident fishery, wildlife, recreation, and hydropower generation. Output from the operation studies are also used to assess the environmental consequences of the alternatives with respect to many of the Yakima basin's aquatic and terrestrial resources.

The following operation studies were conducted for the Storage Study's Draft PR/EIS:

1. Current Yakima Project operation—illustrates the way the Yakima Project is currently operated.

2. No Action Alternative operation—represents the most likely future expected in the absence of implementing any of the "Joint Alternatives."

3. Operation of potential Joint Alternatives:

    - Black Rock Alternative (two operation scenarios)

    - Wymer Dam and Reservoir Alternative (two operation scenarios)

    - Wymer Dam Plus Yakima River Pump Exchange Alternative.

Because the No Action Alternative is comprised of water conservation measures which are being considered for implementation with funding from Title XII of the Act of October 31, 1994, and from other sources, each Joint Alternative is added to the No Action Alternative to assess operation accomplishments.

Each Joint Alternative also included an estimate of future annual municipal water needs of 82,000 acre-feet, part of which is subject to prorationing.

In addition, a natural (unregulated) flow regime for the Yakima, Naches, Cle Elum, Bumping, and Tieton Rivers was developed by modeling the river system without the existing Yakima Project storage reservoirs and diversions and associated return flows. This flow regime has been used in developing instream flow water supply goals.

The water supply goals which the No Action Alternative and the Joint Alternatives are attempting to achieve in the operation studies are the following:

- Instream flow objectives for anadromous fish habitat developed by the Storage Study Technical Work Group (SSTWG), a biologist work group formed to assist on technical matters related to Yakima River basin aquatic habitat. A consensus was reached of desired flows for five reaches for each life cycle season—spring (March-June), summer (July-October), and winter (November-February). The monthly and seasonal flow objectives (cfs) and volumes (acre-feet) are shown in Table 3.1 and Table 3.2.

- A dry-year proratable water irrigation water supply of not less than 70 percent of the proratable water entitlements. Table 3.3 shows the Yakima River basin water entitlements upstream of the Parker gage (RM 104.0) for the period of April-October (irrigation season).

- A future (year 2050) municipal surface water supply of 82,000 acre-feet.

Table 3.1 Monthly flow objectives and volumes for an average water year for the Easton reach, Cle Elum River, and Ellensburg, Wapato, and lower Naches River reaches

Reach		Spring				Summer				Winter			
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Easton	Flow objective (cfs)	722	1,166	1,400	787	450	375	375	375	425	450	450	450
	Volume (a-f)	42,943	69,406	83,300	46,856	26,775	22,313	22,313	22,313	25,288	26,775	26,775	26,775
Cle Elum River	Flow objective (cfs)	511	954	1,500	1,301	589	400	400	400	425	425	425	425
	Volume (a-f)	30,432	56,777	89,250	77,391	35,061	23,800	23,800	23,800	25,288	25,288	25,288	25,288
Ellens-burg	Flow objective (cfs)	1,982	2,424	3,700	2,586	2,000	1,000	1,000	1,000	980	1,016	1,257	1,459
	Volume (a-f)	117,938	144,238	220,150	153,849	119,000	59,500	59,500	59,500	58,311	60,446	74,807	86,821
Wapato	Flow objective (cfs)	3,109	2794	3,500	2655	1,300	1,300	1,300	1,300	1,758	1,854	2,163	2,460
	Volume (a-f)	184,978	166,261	208,250	157,958	77,350	77,350	77,350	77,350	104,616	110,295	128,712	146,389
Lower Naches River	Flow objective (cfs)	1,265	1,802	2,297	2,291	988	550	550	550	500	576	691	720
	Volume (a-f)	75,296	107,194	136,682	136,307	58,772	32,725	32,725	32,725	29,779	34,290	41,112	42,834

Table 3.2. Seasonal flow volume objectives for the Umtanum and Parker gages for an average water year (acre-feet)

Flows	Umtanum gage			Parker gage		
	Spring	Summer	Winter	Spring	Summer	Winter
Flow objective	741,915	304,920	380,010	780,410	316,602	898,766
No Action Alternative	685,946	614,456	380,010	725,734	190,155	698,766
Black Rock Alternative	751,152	476,734	434,527	1,007,651	313,234	758,113
Wymer Dam and Reservoir Alternative	701,927	550,763	418,356	700,894	187,865	689,855
Wymer Dam Plus Yakima River Pump Exchange Alternative	702,532	549,792	418,433	863,031	375,893	690,108
Enhanced Water Conservation Alternative	695,326	604,366	379,163	765,463	195,416	694,414

Table 3.3. Yakima River basin annual water entitlements

Irrigation entity	Annual water entitlements (maf)[1]		
	Proratable	Nonproratable	Total
Kittitas Division	.336		.336
Roza Division	.375		.375
Wapato Irrigation Project	.350	.306	.656
Sunnyside Division	.143	.316	.459
Tieton Division	.038	.076	.114
Other	.042	.519	.561
Total basin	1.284	1.217	2.501

[1] Entitlements used when prorationing of the water supply available for irrigation is required. Conditional Final Orders of the Adjudication Court and Water Right Settlement Agreements have, in some cases, established limitations on the volume that can be diverted in any year.

3.1 Hydrologic Indicators

Reclamation focused on the following hydrologic indicators of the operation study results to assess the success of the alternatives in addressing the primary Storage Study purposes and in comparing these accomplishments among the alternatives.

The April-September TWSA estimate and changes in the estimate are indicators of the water supply available to the Yakima Project upstream of Sunnyside

Diversion Dam to meet all water needs during the major demand season. (Note that during the months of November through March, all demands are a small portion of the unregulated supply available during these months.) The April-September TWSA is comprised of storage contents at the end of March, and runoff and return flows upstream of Parker during this 6-month period.

The only Joint Alternatives that will increase TWSA are those that increase the storage contents by March 31. There is little room for improving the stored water supply with new or existing Yakima basin storage because of winter target flows and the limited runoff above new storage sites. Runoff is fixed by nature. Return flows are a function of irrigation efficiency, and the system improvements included in the analysis are those associated with the delivery systems from the river diversion to the farm turnout. While these efficiency improvements do decrease irrigation diversions, they also reduce return flows, a component of the TWSA.

An increase in the TWSA from one alternative to the next indicates an improvement in the water supply condition, while a decrease shows the opposite. While an alternative may change the volume of the TWSA, in reality there is not much room for improving the basin's water supply by more than a few percentage points. To really achieve improvements to the Storage Study goals, a redistribution of the TWSA is required.

The TWSA is distributed three ways: (1) as flows downstream from Parker, comprised of Title XII flows and undiverted unregulated runoff and operational spills; (2) as irrigation and municipal and industrial (M&I) diversions upstream of Parker; and (3) as carryover of stored water at the end of the irrigation season. Shifting the distribution of TWSA from irrigation and M&I diversions to flows downstream from Parker benefits fisheries. Likewise, by reducing the irrigation demand on the Yakima Project (such as through a water exchange) and shifting more TWSA to storage carryover, dry-year irrigation impacts are reduced.

The volume of the WSAI, which is the irrigation and M&I diversion portion of the TWSA, determines the need for proration. The irrigation proration level is expressed as the percent of the proratable water supply provided as of the end of September in relation to the September proratable entitlement. When comparing alternatives, an increase in the proration level is moving toward a full (100-percent) proratable water supply.

The proration level is an indication of the volume of water that can be diverted from the river. However, this does not account for the increase in the volume of the diversion actually getting to the farm turnout (the farm delivery) as the result of improvements in canal efficiencies. Farm delivery is a better representation of

the volume of water available to meet irrigation demands. The delivery volume shortage represents the difference between a full delivery supply (represented by the median volume delivered for the period of record of 1981-2005) and the volume delivered in a specific year. The change in the delivery shortage is a better indication of the effectiveness of an alternative to insure a full supply for irrigation. It also accounts for the new stored water supply from the Columbia River not captured by the TWSA, as the TWSA only accounts for Yakima Project water supplies.

The flow volume past Parker is a good indicator of the benefits to the Yakima River at Parker, but does not fully reflect what is occurring at the Columbia River confluence. The alternative with the most instream flow benefit would improve flows not only at Parker but at the confluence. This is best represented by changes in the flow volume at the mouth of the Yakima River. For the operation studies this represents the changes in Yakima River discharges immediately below the pumping plant which would be constructed on the Columbia River as a part of the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Hydrologic indicator results obtained from operation study output generated by the Yak-RW model are used to assess operation accomplishments. The Yak-RW model uses the 25-year hydrologic period of historical water years of 1981-2005 and provides daily, monthly, and yearly output for this period.

The No Action Alternative is the focal point from which changes in the hydrologic indicators are measured. The hydrologic indicators used in this document to identify and assess changes in the Yakima Project water supply consist of the 25-year average for the following components:

- Change in the April-September TWSA,
- Change in the TWSA distribution consisting of: (1) April-September flow volume past Parker; (2) April-September total diversion volume upstream of Parker; and (3) September 30 reservoir contents, and
- Change in the April-September flow volume at the mouth of the Yakima River.

The hydrologic indicators used to assess the proratable irrigation supply available in dry years are:

- Irrigation proration level for dry years when the proratable water supply available is less than 70 percent; and

- Change in the irrigation delivery[16] volume shortage for water year 1994, the third year of the 3-year dry cycle.

3.2 Current Yakima Project Operation

The objective of the current operation is to fill the Yakima Project reservoir system to its full active capacity of about 1 million acre-feet, while providing "minimum" flows downstream from the dams, meeting Title XII target flows at Sunnyside and Prosser Diversion Dams, and providing reservoir space for possible flood-control operations. Runoff from the watershed upstream of the five major Yakima Project reservoirs is stored, subject to flood control space requirements, following the end of the irrigation season in October and continuing through the fall, winter, and early spring months to accomplish this objective. Once the reservoirs are full, the inflows are passed through.

The irrigation season starts about the first of April, though the "priming" of the main conveyance canals generally begins by mid-March. During the initial part of the irrigation season, unregulated runoff from tributaries below the five reservoirs along with incidental releases from the reservoirs (for target flows below the dams and for flood control space) is generally adequate to meet irrigation diversion demands and the Title XII instream target flows at Sunnyside Diversion Dam (Parker gage, RM 103.7). Irrigation return flows also contribute to meeting irrigation diversion demands. Figure 3.1, "Yakima River Basin Schematic," shows the Yakima River Basin irrigation diversions and irrigation return flows. On average, unregulated flows and irrigation return flows are adequate in meeting diversion demands until about June 24. The earliest unregulated flows have been unable to meet demands is April 1, and the latest was August 17.

Once the unregulated flows and incidental releases fail to meet diversion demands and Title XII target flows, reservoir releases must be made, resulting in depletions in the stored water supply. The time when this occurs is commonly referred to as the beginning of the storage control period.

From the beginning of the storage control period until the first of September, releases from Cle Elum Lake are used in coordination with releases from the other reservoirs to meet mainstem Yakima River water entitlements extending from the Cle Elum River confluence (RM 179.6) to Sunnyside Diversion Dam (RM 103.8). A major portion (approximately 60%) of these water entitlements are in the

[16] Irrigation delivery is a general term that includes M&I simulated by Yak-RW and future municipal deliveries under the Joint Alternatives.

middle Yakima River basin, from Roza Diversion Dam (RM 127.9) downstream, including the Roza Division, Wapato Irrigation Project (RM 106.7), and the Sunnyside Division. The water entitlements of the foregoing amount to about 1.46 million acre-feet, out of a basin total of about 2.5 million acre-feet upstream of the Parker gage. This results in a high volume of water being transported from the upper to middle basin by the Yakima River. At peak, about 3,600 cfs for irrigation diversion is being moved through this area.

However, about September 1, the Yakima Project moves into what is called the "flip-flop" operation. At this time, Cle Elum Lake releases are substantially reduced over a 10-day period (from about 3,000 cfs to 220 cfs). During this interval, releases from Rimrock Lake are substantially increased to meet the September-through-October irrigation entitlements downstream from the confluence of the Naches and Yakima Rivers (from about 1,000 cfs to 2,000 cfs); the major portion of which is the Wapato Irrigation Project and the Sunnyside Division. The purpose of the flip-flop operation is to cause upper Yakima River spring Chinook to spawn in areas that will remain covered by low flows throughout the fall and winter in the upper Yakima River (RM 156 to RM 202) and the Cle Elum River, rather than in areas which would otherwise (without flip-flop) be dewatered at the end of the irrigation season when irrigation releases from the reservoirs would be stopped. Flip-flop allows protection of the redds, or incubating eggs, throughout the fall and winter months while minimizing lesser water releases from storage, thus improving the stored water supply for the next irrigation season.[17]

A similar operation, referred to as "mini flip-flop," is performed between Keechelus and Kachess Lakes in years of sufficient water supply. During the main spawning months, greater releases are made from Keechelus Lake to meet the upper basin demands (primarily the Kittitas Reclamation District), and releases from Kachess Lake are restrained. Then, beginning in late August and continuing through October, the opposite is done, with greater releases being made from Kachess to meet upper basin demands and releases from Keechelus being reduced to provide sustainable spawning flows in the Yakima River reach from Keechelus Dam (RM 214.5) to the backwaters of Lake Easton (about RM 203.5).

Concurrent with the September shift in major water releases from Keechelus Lake to Kachess Lake, Kittitas Reclamation District's main canal (which has excess carrying capacity due to lower September demands) is used to convey water for downstream use (such as the Roza Irrigation District) around the Easton Reach.

[17] A detailed history and description of the flip-flop river operation, instituted in the early 1980s, can be found in the *Interim Comprehensive Basin Plan* (Reclamation, 2002)

This water reenters the Yakima River through the 1146 Wasteway,[18] approximately 28 miles downstream from Easton Diversion Dam. This operation provides an average spawning flow of approximately 220 cfs for spring Chinook through the Easton reach.

[18] The 1146 Wasteway conveys excess water from KRD's main canal to the Yakima River at RM 173.9.

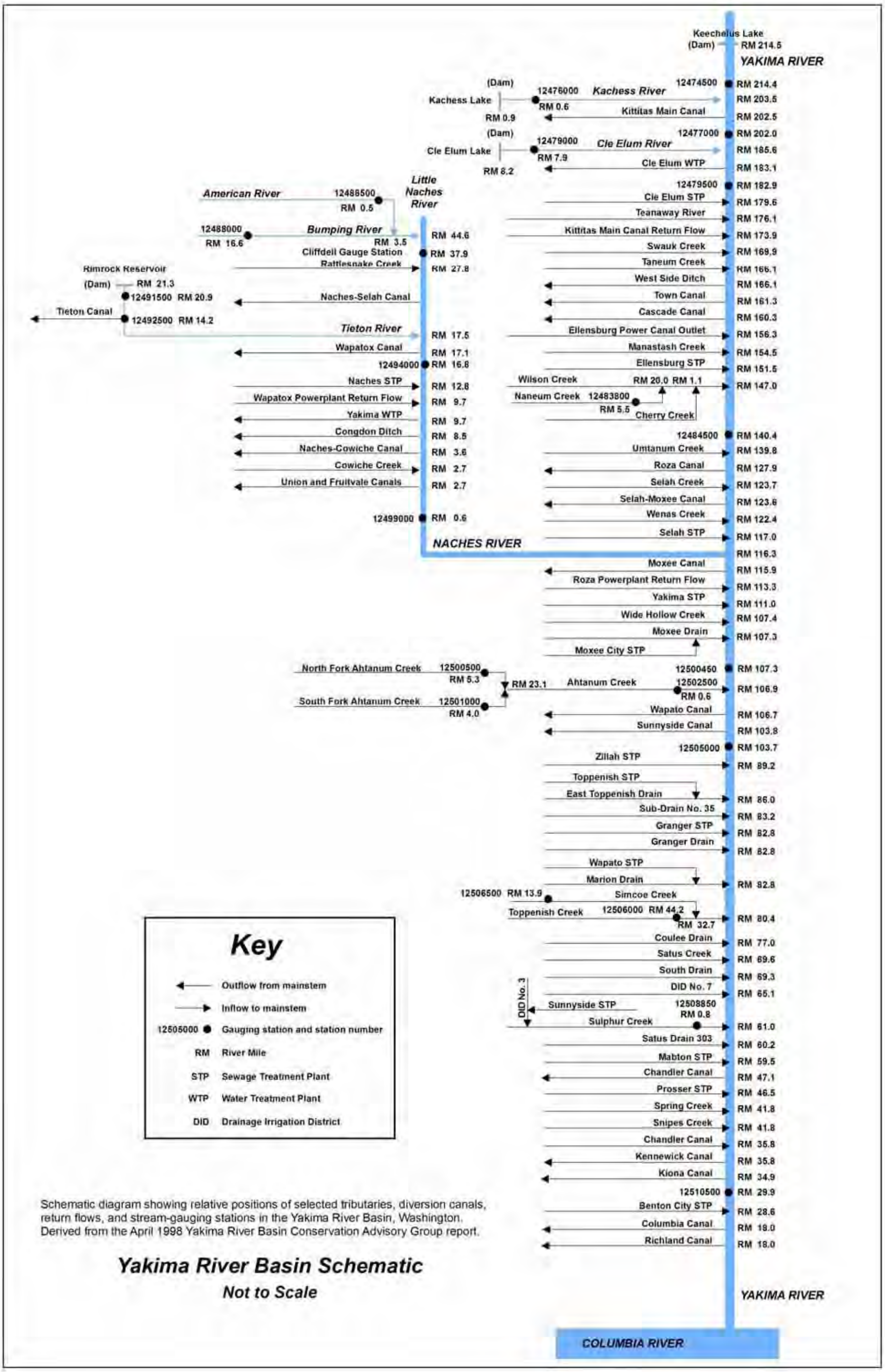

Figure 3.1. Yakima River Basin Schematic

3.3 No Action Alternative Operation

The No Action Alternative includes the current operation combined with the future implementation of voluntary water conservation measures by Yakima basin entities through financing under the Basin Conservation Program of Section 1203 and under Section 1204 of the Yakama Reservation of Title XII of the Act of October 31, 1994 (Title XII), and through other sources. Conserved water resulting from water conservation measures is determined as the reduction in the entity's delivery system losses from the point of diversion to the "last" point of operational discharge. Water conserved by measures implemented with Basin Conservation Program financing is assigned two-thirds to instream flows and one-third to irrigation; the irrigation portion is retained by the implementing entity.

Changes to the hydrology during the irrigation season as the result of entities implementing water conservation measures in the Yakima basin is discussed below.

April-June - Generally, in the April-June part of the irrigation season, irrigation demands are met from unregulated flows and the minimum Yakima Project reservoir releases. Because diversions are mostly from unregulated streamflows during this period, all of the conserved water remains instream, increasing flows in the specific reach of the river from which the conservation action of reduced diversions occurred, to the last point of return flow influence from the conservation action.

July-October - Once unregulated streamflows fail to meet diversion demands and Title XII target flows at Parker, reservoir storage releases must be made to meet these demands, depleting reservoir contents. Prior to conservation, the July-October portion of the volume of water labeled "conserved" under the No Action Alternative would have been a part of the entity's water supply being released from storage. In the No Action Alternative with water conservation, storage releases continue to be made but only for the instream flow portion of the conserved water. These instream flow releases improve the flow in the specific reaches where the conservation measures were implemented. However, the irrigation portion of the conserved water which would have been provided by reservoir releases can be retained in storage in wet and average years but, in dry years, is released for use by the conserving entity.[19] In some instances, depending on the extent of the conservation activities, additional stored water may have to be

[19] Retention of the irrigation portion in the reservoirs in wet and dry years will reduce instream flows downstream from the dam to the point of diversion.

released if diverters downstream from the reach where water conservation occurred were being "shorted" of their water supply because of decreased return flows.

Title XII sets instream target flows downstream from Sunnyside Diversion Dam in wet and average water years at 400 to 600 cfs, depending on the TWSA estimates; in dry years, the target flow is 300 cfs. (The TWSA estimates and the range of instream target flows are shown in Table 2.8.)

If the point of diversion and the last point of return flow influence include a river reach encompassing points both upstream and downstream of Sunnyside Diversion Dam, then the Title XII Parker target flows are increased by the instream flow portion of the conserved water. A conservation measure that results in a change in diversion location (point of diversion) from upstream to downstream of Sunnyside Diversion Dam is not considered an increase to the Title XII Parker target flow; however, it would physically increase flows over Sunnyside Diversion Dam.

3.3.1 Entity Water Conservation Measures

Following enactment of Title XII and development of the *Basin Conservation Plan* by the Yakima River Basin Conservation Advisory Group (1998), which provides the "road map" for implementation of the Water Conservation Program, Yakima basin irrigation entities who desired to participate in the Basin Conservation Program submitted water conservation plans to Reclamation. Twelve plans were submitted for consideration.[20] Reclamation evaluated these water conservation plans, and measures from four plans were approved for feasibility investigations, which are a prelude to actual implementation. Generally, the approved measures comprise all or some of the priority measures identified in the *Basin Conservation Plan*. To date, feasibility investigations have been completed by two entities (Sunnyside Division and Benton Irrigation District). Some measures of the Sunnyside Division plan have been implemented and completed.

The water conservation measures included in the No Action Alternative are those from the entities' plans that were approved for feasibility investigations or are currently being further considered for possible inclusion in the *Basin Conservation Plan*. Additional measures are being considered for funding from other sources as well as water conservation activities in the Wapato Irrigation

[20] Seven water conservation plans were prepared with partial funding provided from the Basin Conservation Program. Five water conservation plans were developed with State of Washington Referendum 38 financing.

Project which provides irrigation service to lands within the Yakama Nation Reservation.[21] A description of the water conservation measures and estimates of the conserved water follows.

3.3.1.1 Kittitas Reclamation District

The Kittitas Reclamation District diverts from the upper Yakima River area at Easton Diversion Dam (RM 202.5) into the Kittitas Main Canal. KRD's water conservation program consists of piping about 70 miles of open lateral systems where high water losses have been a problem, constructing two reregulating reservoirs, and installing flow control structures to automate the North and South Branch Canals and Wippel Pumping Plant in conjunction with the reregulation reservoirs. The proposed use of the instream flow portion of the conserved water is flow enhancement in Taneum Creek, Big Creek, or Little Creek, to be conveyed by the Main Canal for discharge to the creek(s). This action results in additional Yakima River streamflows beginning from the Big Creek confluence, increasing with the confluence with Little Creek and Taneum Creek, to the last return flow influenced by KRD diversions near Yakima Canyon (about RM 147).

3.3.1.2 Roza Irrigation District

The Roza Irrigation District's point of diversion is in the middle Yakima River area at Roza Diversion Dam (RM 127.9). RID's water conservation measures in the Basin Conservation Program involve the proposed construction of a reregulation reservoir at Roza Canal Wasteway No. 5. This action would increase flows by about 26 cfs in the Yakima River from Roza Diversion Dam to Swiss Corral Creek (RM 34.3) and result in increased Title XII target flows at Parker by 26 cfs.

In addition, the RID water conservation plan includes measures which it proposes to fund under a "pay as you go approach" using district monies accumulated for water conservation purposes and financing available from other programs. In the past, RID has used this approach and proposes to continue it in the future so they can retain all of the conserved water rather than getting only one-third when funding is provided from the Basin Conservation Program. Thus, the district direct-funded measures are not considered to increase Title XII Parker target flows.

[21] The proposed water conservation measures on the Yakama Nation Reservation are being considered for implementation as a part of Section 1204(a)(2) of Title XII, which authorized an appropriation of $23 million. Section 1204(a)(3) of Title XII provides that conserved water shall be available for use by the Yakama Nation for irrigation and other purposes on the reservation or for protection and enhancement of fish and wildlife within the Yakima River basin.

3.3.1.3 Union Gap Irrigation District

The Union Gap Irrigation District (UGID) diversion is a joint diversion with the Fowler Ditch Company in the middle Yakima River area (RM 114.7). UGID's water conservation plan consists of constructing a river pump station approximately 11 miles downstream from its existing diversion for pressurized service to downstream lands. The existing diversion dam and canal would continue to be used to serve UGID lands upstream from the Fowler Ditch Company. This change in point of diversion would result in operational flows being left in the Yakima River from RM 114.7 to RM 105.0. The instream flow portion of the conserved water (10 cfs) resulting from construction of the new pump station and pressurized delivery system would then remain in the Yakima River to the Spring Creek Wasteway (RM 41.8). The instream flow of 10 cfs is considered an increase to Title XII Parker target flows.

3.3.1.4 Wapato Irrigation Project

The Wapato Irrigation Project (WIP) obtains its Yakima Project water supply by diversions at Wapato Diversion Dam (RM 106.7) in the middle Yakima River. The proposed water conservation measure consists of changing the point of diversion for the Satus lands, which are located in the lower end of the Yakama Nation Reservation. The current irrigation water source for these lands is partially from diversions at the Wapato Diversion Dam and return flows from irrigated lands which are captured in the Marion Drain and Wanity Slough and then pumped to the Satus lands. For the No Action Alternative, this conservation is estimated as a change of 50 cfs from WIP's current diversion (RM 106.7) to a new location near Satus Creek (RM 70). The 50 cfs would flow past Parker, but is not considered an increase to Title XII Parker target flows.

3.3.1.5 Sunnyside Division

The Sunnyside Division's diversion is at Sunnyside Diversion Dam (RM 103.9), the last diversion in the middle Yakima River area.

The Sunnyside Division Water Rights Settlement Agreement between the United States, the Yakama Nation, and Ecology in 2001 provides for implementation of a Phase 1 water conservation program that will provide about 29,100 acre-feet of conserved water, resulting in a diversion reduction of 19,450 acre-feet (54 cfs) to be realized not later than December 31, 2016. This diversion reduction would be for instream flow purposes, and the residual 9,700 acre-feet of the total conserved water would be retained for irrigation use by the Sunnyside Division.

The water conservation measures included in this Phase 1 activity consist of replacement of 28 existing check structures in the canal and the addition of two

new checks, all with fully automated electrically powered gates; construction of three reregulation reservoirs, each with an inlet chute drop structure, pump station, and control system automation of canal spillway gates; and a radio communication system between the central office and the automated control sites. This action results in about 54 cfs remaining in the Yakima River between the Sunnyside Diversion Dam (RM 103.8) and Spring Creek (RM 41.8).

The Water Rights Settlement Agreement also provides for a further diversion reduction of 16,500 acre-feet (46 cfs) at some unspecified future date to be used for instream flow purposes. The conserved water would be about 24,700 acre-feet, of which 8,200 acre-feet would be retained by the Sunnyside Division. This activity is to be accomplished by a Phase 2 water conservation program, and the Sunnyside Division is exploring opportunities to use funding from the Basin Conservation Program.

The additional instream flows resulting from Phase 1 and 2 activities are considered to result in an additional 100 cfs added to the Title XII Parker target flow.

3.3.1.6 Benton Irrigation District

The Benton Irrigation District (BID) is currently a part of the Sunnyside Division and its water supply is diverted at Sunnyside Diversion Dam and conveyed through the Sunnyside Main Canal for delivery to BID. The water conservation program involves construction of a Yakima River pump station just upstream from Benton City (RM 32.1) and a pressurized pipeline distribution system.

Because of the diversion change, operational flows of about 58 cfs would remain in the 72-mile reach of the Yakima River from Sunnyside Diversion Dam to the new pumping station. At this point, water would be pumped to the pressurized delivery system. The instream flow portion of the conserved water (about 11 cfs) would then remain in an 8.3-mile reach of the Yakima River from the pumping station to the point of operational spills at RM 23.8. BID's change in point of diversion results in a decrease in diversions by the Sunnyside Division of about 21,000 acre-feet.

3.3.1.7 Naches-Selah Irrigation District

The water conservation program of the Naches-Selah Irrigation District (NSID) involves abandoning their current Naches River point of diversion (RM 18.4) and diverting at the Wapatox Ditch Company's diversion (RM 17.1). The Wapatox Canal has been used to deliver water to the Wapatox Ditch Company as well as water for hydropower generation at Pacific Power and Light Company's

powerplants. The water for hydropower generation has been used as "carriage water" for the Wapatox Ditch Company.

Reclamation acquired the hydropower water rights on March 10, 2003, as a part of the water acquisition program of Title XII. With this acquisition, there is adequate capacity in the Wapatox Canal to convey NSID water to a point where a new pump station could lift water to its existing conveyance system. The effect of this action is threefold—first, it removes a diversion from the Naches River; second, it results in an additional 100 cfs remaining in the Naches River from RM 18.4 to RM 17.1 because of the proposed change in diversion; and third, it allows the NSID water to be used as conveyance water for the Wapatox Ditch Company.[22] This permits the full Pacific Power and Light Company's water right acquired by Reclamation (estimated at an average flow of 370 cfs) to remain in the Naches River for a 7.4-mile reach—from the Wapatox Ditch diversion (RM 17.1) to the prior powerplant discharge (RM 9.7).

3.3.2 Summary Water Conservation Measures

Table 3.4 provides information on the conserved water resulting from the water conservation measures that comprise the No Action Alternative. The table also shows the distribution of the conserved water to instream flows and that retained by the entity for irrigation use in dry years. The conserved water volumes are subject to prorationing based on each entities' ratio of nonproratable and proratable entitlements.

Table 3.5 shows information for the Middle Yakima River area on the additional instream flows resulting from the water conservation measures. The information shown represents the increased streamflows for nonproration water years during the storage control period of Yakima Project operations discussed in section 3.2 of this report. Water conserve ation measures implemented in the Middle Yakima River area for which the last point of the entities' operational discharge is downstream from Sunnyside Diversion Dam are the only ones that will result in an increase in the Title XII target flows at Parker.

Implementation of the water conservation measures of the No Action Alternative will result in an increase of the Title XII target flows at Parker by 136 cfs in wet and average water years. This will increase the target flows from the current range of 400-600 cfs in wet and average years to 536-736 cfs. In dry years, the

[22] The 100-cfs increase in streamflow between NSID's current diversion (RM 18.4) to the Wapatox Canal diversion (RM 17.1) was inadvertently not included in the No Action Alternative operation study. However, the increased streamflow associated with the power right acquisition was included.

flow is 300 cfs, and the increased 136 cfs flow would be adjusted according to the proratable entitlements of the entities participating in the Basin Conservation Program. In a dry year such as 1994, the 136 cfs would be adjusted to about 97 cfs.

Operational flows associated with changes in entity points of diversion will result in an additional flow of 108 cfs passing Sunnyside Diversion Dam in wet and average water years. These operational flows are also adjusted in dry years in accordance with the entitlements.

Table 3.4. Conserved water resulting from conservation measures

Entity	Action	Conserved Water					
		Volume (acre-feet)			Flow (cfs)		
		Total	Instream	Irrigation	Total	Instream	Irrigation
Upper Yakima River Area							
KRD	System Improvements	47,800	31,700	16,100	132	88	44
Middle Yakima River Area							
RID	System Improvements under Basin Conservation Program	13,700	9,200	4,500	37	26	11
	System Improvements with "pay as you go approach"	30,000	NA	30,000	82	NA	82
	Total	43,700	9,200	34,500	119	25	94
UGID	Change in Diversion	13,000			36		
	System Improvements	5,600	3,700	1,900	15	10	5
WIP	Change in Diversion				50	50	
Sunnyside	System Improvements (1)	29,100	19,400	9,700	80	54	26
	System Improvements (2)	24,700	16,500	8,200	68	46	22
	Total	53,800	35,900	17,900	148	100	48
Benton ID	Change in Diversion	21,000			58		
	System Improvements	6,300	4,200	2,100	17	11	6
Naches River Area							
NSID	Change in Diversion				100		
Total No Action Alternative		157,200	84,700	72,500			

Note: The change in diversion represents the amount the current diversion is reduced. This amount becomes an operational flow in the river reach between the current and new diversion points.

Table 3.5. Middle Yakima River area instream flow during the storage control period associated with water conservation measures (TM 127.9 to 103.7)

			Instream Flow (cfs)			Elements of Instream Flow (Cumulative) (cfs)	
Entity	**Action**	**River Mile**	**Accretion**	**Depletion**	**Cumulative**	**Title XII**	**Operational**
RID	System Improvements	127.9	26		26	26	
UGID	Change in Diversion	114.7	36		62		36
WIP	Change in Diversion	106.7	50		112		86
UGID	New Diversion	105.0		-36	76		50
	System Improvements	105.0	10		86	10	
Sunnyside	System Improvements	103.8	100		186	136	
BID[23]	Change in Diversion	103.8	58		244		108
Flow at Parker		103.7[24]					
Title XII Increase						136	
Operational							108

3.3.3 Operation Criteria

The No Action Alternative operation criteria are the same as the current Yakima Project operation with the following exceptions:

- The irrigation diversions of entities included in the No Action Alternative water conservation measures are reduced in wet and average water years by the total volume of conserved water (157,200 acre-feet). In dry years, the diversion reduction reflects only the instream flow portion of the conserved water (84,700 acre-feet). In the operation study, the irrigation portion (72,500 acre-feet) is assumed to be diverted by the entity (see Table 3.4).

[23] The Benton Irrigation District instream flow portion (11 cfs) of the conserved water increases streamflows in the Yakima River from the new point of diversion (RM 32.1) to the last point of return flows (RM 23.8).

[24] RM 103.7 is the Parker gaging station, a short distance downstream from Sunnyside Diversion Dam.

- During the first part of the irrigation season when diversions are being met from unregulated flows (generally April-June), all conserved water remains in the river. However, once the storage control period begins, the irrigation portion provided from storage is not released from Yakima Project reservoirs in wet and dry water years. This volume is carried over at the end of the irrigation season and improves the stored water supply in subsequent years. However, once carried over, it loses its identity to a specific entity and becomes a part of the TWSA.

- No specific stored water releases are required in the No Action Alternative operation to "make up" return-flow deficiencies downstream from the river reaches where conservation measures are implemented.

The entity diversions inputted to the Yak-RW model are described in Part I, Section 2.1.4. Table 3.6 shows the No Action Alternative diversions in a nonprorated water year.

Table 3.6. Annual diversions for entities included in the No Action Alternative for a nonprorated year (acre-feet) (data from Yak-RW model)

	Kittitas Division	Roza Division	Sunnyside Division	Wapato IP	Union Gap ID
Average Diversion	334,500	346,500	435,400	604,800	13,000
Less: Total Conserved	-47,800	-43,700	-53,800	N/A	-3,800
Less: Benton ID	N/A	N/A	-21,000	N/A	N/A
No Action Diversion	286,700	302,800	360,600	604,800	9,200

3.3.4 Comparison of Operation Studies

3.3.4.1 Hydrologic Indicators

Table 3.7 presents the differences in the hydrologic indicators between the No Action Alternative and the current operation.

With the current operation, there are 6 years when the proration level is less than 70 percent. In 5 of these years, the proration level is improved with the No Action Alternative; however, as indicated in Table 3.8, in the third year (1994) of the 3-year dry cycle of 1992-1994, it is not. There is some improvement in the irrigation delivery shortage, indicating that in a dry year, more water is being delivered to the farm turnout as the result of the water conservation measures included in the No Action Alternative.

The overall result is that when moving from the current operation to the No Action Alternative, implementation of water conservation measures reduces the

irrigation diversion demands, resulting in (1) increased instream flows downstream from Parker; and (2) increased September 30 reservoir carryover due to retaining some of the irrigation portion of the conserved water in the reservoir when going into the winter operation. This is essentially a redistribution of the TWSA by decreasing diversions, increasing instream flows downstream from Parker, and improving storage carryover.

Table 3.7. Changes in hydrologic indicators—No Action Alternative compared to current operation (data from Yak-RW model) (changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA distribution			Apr-Sep Yakima flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima flow volume at Parker gage	Apr-Sep diversion volume up-stream of Parker gage	Sep 30 reservoir contents			
	(maf) and % change						Proration and % change
Average year 1981-2005 (results from Yak-RW model)							
Current operation	2.82	0.51	2.02	0.27	0.85	0.07	
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Change from current operation	0.02	0.11	-0.11	0.03	0.01	-0.02	
% change	1%	22%	-5%	11%	1%	-28%	
Dry year 1994 (results from Yak-RW model)							
Current operation	1.75	0.19	1.49	0.07	0.32	0.40	28%
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Change from current operation	0.00	0.06	-0.07	0.00	-0.01	-0.02	-1%[2]
% change	0%	31%	-5%	0%	-3%	-5%	

[1] The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record 1981-2005) and the volume delivered in a specific year.

[2] The irrigation water supply benefits of the conservation actions are realized in 1992 and 1993 as shown by the improved irrigation proration levels of the No Action Alternative. By 1994, the third year of the dry cycle, the difference in the proration level of the No Action Alternative and the current operation is negligible and is due to rounding of the Yak-RW model results.

Table 3.8. Change in irrigation proration level

Water year	Proration level (percent)		
	Current	No Action Alternative	Change w/ No Action Alternative
1987	64	69	5
1992	68	70	2
1993	56	57	1
1994	28	27	-1
2001	40	44	4
2005	38	45	7

3.3.4.2 Instream Flows

The Title XII target flows downstream from Sunnyside Diversion Dam (at Parker) are increased by 136 cfs, resulting in the following target flows shown in Table 3.9. In addition, there are operational flows of 108 cfs as the result of changes in points of diversion from upstream to downstream of Sunnyside Diversion Dam by some of the entities in the No Action Alternative.

Table 3.9. Changes in Title XII target flows downstream from Sunnyside Diversion Dam—current Yakima Project operations compared to No Action Alternative

Total Water Supply Available estimate (maf)				Title XII target flow at Parker (cfs)	
Apr - Sep	May - Sep	Jun - Sep	Jul - Sep	Current	No Action
3.2	2.9	2.4	1.9	600	736
2.9	2.65	2.2	1.7	500	636
2.65	2.4	2.0	1.5	400	536
Less than above				300	*

*In dry water years, the target flow is 300 cfs and the 136 cfs increase is adjusted according to the water rights of the entities participating in the Basin Conservation Program. In a dry year such as 1994, the target flow would be 394 cfs.

3.4 Operations of Potential Action Alternatives

This section describes the operations of the Joint Alternatives:

- Black Rock Alternative (with two operation options)
- Wymer Dam and Reservoir Alternative (with two operation options),
- Wymer Dam Plus Yakima River Pump Exchange Alternative.

First, a summary of the alternative and an overview of the major components and annual operations is provided; second, the operation criteria is described; third,

information is provided on reservoir operations consisting of river flows available for withdrawal, pumping to the reservoir, reservoir releases, and reservoir storage contents; and fourth, the hydrologic indicators of each alternative are compared to the No Action Alternative and the changes summarized. The municipal water supply operations and accomplishments are then addressed for all of the alternatives in section 3.5.

3.4.1 Black Rock Alternative

The Black Rock Alternative involves an exchange of Columbia River water for Yakima Project water currently diverted by the Roza and Sunnyside Divisions (Roza and Sunnyside) from the Yakima River for irrigation of about 172,000 irrigable acres parallel to and north of the Yakima River extending through the eastern portion of the middle and lower valley areas of the Yakima Project. Columbia River water pumped from the Priest Rapids Lake would be stored in a Black Rock reservoir to be constructed in Black Rock Valley. Stored water would be conveyed by an outflow conveyance system extending from the reservoir to the lower Yakima Valley and delivered to Roza Canal at MP 22.6 for Roza's downstream users and to the Sunnyside Canal at MP 3.83 for Sunnyside's upstream and downstream users. Most of the Yakima Project water currently diverted from the Yakima River by these two water exchange participants would not be diverted and that water would remain in the river to improve the aquatic resources.

3.4.1.1 Overview of Facilities and Operations

The Black Rock Alternative consists of an intake structure on the right bank of Priest Rapids Lake with an intake channel extending to Priest Rapids pumping plant, housing three 500-cfs and two 1,000-cfs pumps (total capacity of 3,500 cfs). Water would be lifted by the pumping plant through a manifold connected to a 17-foot-diameter tunnel sloping upward to Black Rock reservoir. The tunnel portal would be just outside of the pumping plant switchyard at an elevation of 495 feet with the tunnel terminus at elevation 1,440 feet, a distance of about 6.5 miles.

The Black Rock reservoir would be located in the Black Rock Valley with a total active capacity of 1.3 million acre-feet at elevation 1,775.0 feet; inactive capacity is about 157,000 acre-feet at elevation 1,500 feet. Stored water would be released into a 2,500-cfs, 17-foot-diameter tunnel/pipeline outflow conveyance system extending about 3.5 miles to MP 22.6 of the Roza Canal. At this point, some of the flow would be discharged to downstream lands of the Roza Division through a new Black Rock powerplant (23 MW) with the residual flow continuing to MP 3.83 of the Sunnyside Canal.

The Sunnyside pipeline extends from the vicinity of Roza Canal MP 22.6 about 6.5 miles over Konnowac Pass to the Sunnyside Canal at MP 3.83. At this point, most of the water is discharged through a new Sunnyside powerplant (29.5 MW) into the Sunnyside Canal for downstream delivery. However, a small number of water users upstream of this point would receive 17 to 20 cfs by a pumping plant and buried PVC pipeline extending about 3.2 miles to be located on the right embankment of the Sunnyside Canal.

Roza lands upstream of MP 22.6 would continue to obtain their water supply from the Yakima River by diverting at the Roza Diversion Dam (RM 127.9). This diversion would continue to provide flows (up to 1,020 cfs) for the operation of the Roza Powerplant and the approximately 180-200 cfs required for irrigation by Roza lands upstream of Roza Canal MP 22.6.

Pumping from Priest Rapids Lake would occur anytime there is Columbia River water available in excess of current instream target flows and storage space is available in Black Rock reservoir, with the exception of July and August when no Columbia River withdrawals would occur. The operation objective is to maintain Black Rock reservoir at full capacity to assure the water exchange during the April-October irrigation season.

Black Rock reservoir releases begin in April with the start of the Yakima Project irrigation season and continue through late October. During the spring months of April-June, reservoir depletions can, to some extent, be replaced by pumping if Columbia River flows in excess of the instream target flows are available. However, during the peak demand months of July and August when the Black Rock reservoir release volume is generally about 110,000 acre-feet, pumping is not permitted and reservoir contents are depleted without subsequent refill. The maximum volume that can be pumped by the Priest Rapids pumping plant in any month is about 215,000 acre-feet, and maximum pumping generally occurs in September and October to refill this depleted storage space.

Black Rock reservoir releases total about 600,000 acre-feet annually. Reservoir contents are generally at maximum pool prior to the beginning of the irrigation season and at minimum pool at the end of August.

3.4.1.2 Operation Criteria

Two Black Rock operation studies were conducted for the Draft PR/EIS—"Black Rock 1" and "Black Rock 2." Both of the operation studies provide April-October irrigation water from the Yakima River to Roza Division lands upstream of Roza Canal (MP 22.6); downstream lands will be provided water from Black Rock reservoir. March diversions for "priming of the canals" will continue to be diverted from the Yakima River.

The primary difference in the two operations is the extent of the water exchange with the Sunnyside Division. This is shown below:

3.4.1.2.1 Black Rock 1 Operation

Roza Division: The water supply for lands upstream of Roza Canal MP 22.6 is diverted from the Yakima River. The water supply for lands downstream from Roza Canal MP 22.6 is delivered from Black Rock reservoir.

Sunnyside Division: A continuous water exchange during the April-October irrigation season.

3.4.1.2.2 Black Rock 2 Operation

Roza Division: No change from the Black Rock 1 Operation.

Sunnyside Division: When the April 1 TWSA is greater than 3.2 million acre-feet, Yakima River flows in excess of the Black Rock Alternative operation criteria for target flows at the Parker gage can be diverted from the Yakima River at Sunnyside Diversion Dam. Any residual supply necessary to meet Sunnyside Division's irrigation demands is delivered from Black Rock reservoir.

3.4.1.3 Reservoir Operations

3.4.1.3.1 Black Rock Reservoir

The *Federal Columbia River Power System* (FCRPS) *2004 Biological Opinion* (BIOP) prepared by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS, 2004) establishes seasonal flow targets downstream from Priest Rapids, McNary, and Bonneville dams.[25] Target flows facilitate spawning, downstream passage of juveniles, and accommodate returning adult salmon and steelhead. FCRPS operations also include other flow objectives (not part of the BIOP) for nonlisted salmon downstream from Priest Rapids Dam at Venita Bar. and Figure 3.2 summarize these seasonal targets.

[25] These are identical to the December 2000 BIOP.

Table 3.10. Seasonal flow targets and planning dates for the mainstem Columbia River

Columbia River location	Fall through spring targets		Summer targets	
	Dates	Flow (cfs)	Dates	Flow (cfs)
At Priest Rapids Dam - transport target[1]	4/10 - 6/30	135,000	NA	NA
At Priest Rapids Dam - spawning target[2]	10/10 - 6/30	55,000	NA	NA
At McNary Dam - transport target[1]	4/10 - 6/30	[3]220,000 - 260,000	7/01 - 8/31	200,000
At Bonneville Dam - spawning target[1]	11/1 – 4/30	[4]125,000 - 160,000	NA	NA

[1] As per NMFS (2004) for listed species.
[2] Pertains to nonlisted species (Chinook salmon) as per Vernita Bar Agreement; would govern in October; after 4/10, the 135,000-cfs minimum governs.
[3] Objective varies according to water volume forecasts.
[4] objective varies based on actual and forecasted water conditions.

The water supply for Black Rock reservoir is obtained by pumping from the Priest Rapids Lake when mainstem Columbia River flows are available. This occurs when the flows are greater than the seasonal instream target flows. In addition, the State of Washington, as a part of their Columbia River Basin Water Management Program, has indicated that withdrawal of water from the Columbia River for out-of-stream uses in July and August is prohibited.

Table 3.11 provides the average monthly volumes of water in the vicinity of Priest Rapids Dam after all the instream target flow assumptions are met downstream. These volumes may be available for diversion to Black Rock reservoir under water supply conditions similar to those of water years 1981-2005.[26]

The Black Rock 2 operation is used in the Draft PR/EIS. The reservoir operations for Black Rock 1 and Black Rock 2 are different in that annual pumping from the Columbia River to maintain water storage in Black Rock reservoir is somewhat less with the Black Rock 2 operation. This is because of the opportunity to use Yakima River water in wet years to meet part of the Sunnyside Division diversions. The Black Rock 2 operation results in a lower volume pumped of about 1-million acre-feet for the 25-year period of 1981-2005.

[26] The monthly average water supply for this analysis is assumed to be available for each day of the month.

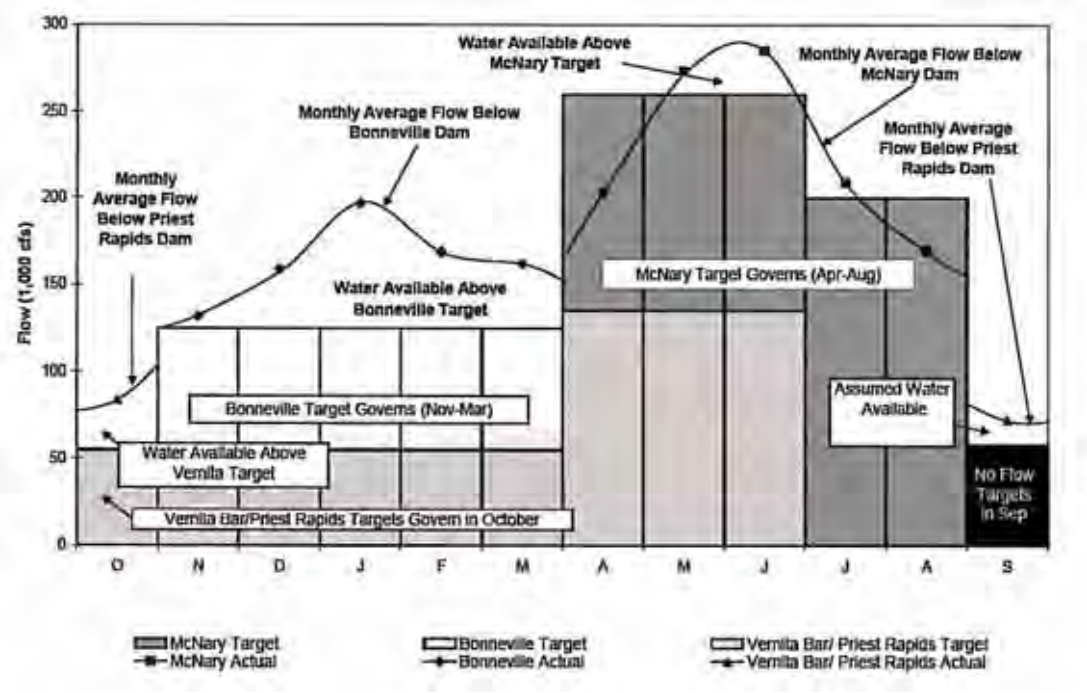

Figure 3.2. Flow targets on the Columbia River and water availability above flow targets.

Table 3.11 Columbia River volumes available for pumping (acre-feet) for the 25-year period of record (1981-2005)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	3,471,000	7,138,000	3,483,000	1,184,000	0	0	5,199,000	No pumping per Columbia River Water Basin Management Program	No pumping per Columbia River Water Basin Management Program	1,413,000	1,674,000	23,562,000
1982	0	1,354,000	5,289,000	3,658,000	4,584,000	311,000	3,983,000	9,600,990			2,625,000	1,886,000	33,290,990
1983	0	2,112,000	5,911,000	2,314,000	5,548,000	52,5000	2,567,000	207,000			1,346,000	1,016,000	21,546,000
1984	2,336,000	1,356,000	5,746,000	1,143,000	2,503,000	371,500	0	2,170,000			938,000	1,063,000	17,626,500
1985	268,000	1,057,000	4,440,000	117,000	914,000	290,500	1,395,000	0			332,000	1,40,8000	10,221,500
1986	190,000	0	4,585,000	1,467,000	4,553,000	1,048,500	0	666,000			330,000	911,000	13,750,500
1987	0	0	1,596,000	207,000	926,000	0	0	0			239,000	1,244,000	4,212,000
1988	0	0	0	0	0	0	0	0			1,067,000	1,400,000	2,467,000
1989	0	0	227,000	0	207,000	205,500	791,000	0			484,000	1,314,000	3,228,500
1990	0	599,000	5,324,000	2,772,000	1,647,000	749,000	0	2,261,000			939,000	1,329,000	15,620,000
1991	1,266,000	2,326,000	6,649,000	5,141,000	1,477,000	0	1,737,000	305,000			1,311,000	1,593,000	21,805,000
1992	0	0	0	1,618,000	46,000	0	0	0			481,000	1,649,000	3,794,000
1993	0	0	0	0	0	0	0	0			637,000	1,475,000	2,112,000
1994	0	0	399,000	0	0	0	0	0			578,000	1,481,000	2,458,000
1995	0	0	576,000	2,466,000	3,262,000	156,000	998,000	0			1,577,000	1,774,000	10,809,000
1996	2,275,000	6,778,000	6,023,000	7,962,000	6,077,000	1,583,500	4,843,000	3,723,000			1,233,000	1,500,000	41,997,500
1997	0	2,033,000	6,221,000	6,792,000	5,145,000	1,541,000	10,186,990	11,865,990			2,745,000	4,342,000	50,871,980
1998	1,277,000	1,039,000	5,063,000	1,574,000	1,415,000	0	131,000	4,259,000			442,000	4,113,000	19,313,000
1999	1,720,000	3,145,000	4,376,000	4,330,000	4,320,000	735,500	1,290,000	3,407,000			3,492,000	1,230,000	28,045,500
2000	4,000	2,659,000	4,896,000	3,763,000	3,084,000	1,042,000	0	0			1,938,000	2,469,000	19,855,000
2001	1,807,000	4,987,000	469,000	308,000	36,000	0	0	0			818,000	1,487,000	9,912,000
2002	403,000	1,241,000	1,133,000	1,319,000	444,000	436,000	0	3,839,000			1,282,000	562,000	10,659,000
2003	0	0	0	822,000	2,091,000	424,500	0	0			657,000	1,691,000	5,685,500
2004	110,000	0	1,081,000	789,000	449,000	0	0	0			1,359,000	1,620,000	5,408,000
2005	50,000	868,000	1,390,000	1,043,000	438,000	0	0	0			796,000	1,774,000	6,359,000
Avg	468,240	1,401,000	3,141,280	2,123,520	2,014,000	376,780	1,116,880	1,900,119			1,162,360	1,680,200	15,384,379
Min	0	0	0	0	0	0	0	0			239,000	562,000	2,112,000
Max	2,336,000	6,778,000	7,138,000	7,962,000	6,077,000	1,583,500	10,186,990	11,865,990			3,492,000	4,342,000	50,871,980

Table 3.12 is the monthly pumping for the Black Rock 2 operation of the portion of the available Columbia River water needed to replenish Black Rock reservoir contents as the result of annual depletions associated with deliveries to the water exchange participants and reservoir and seepage losses. The operation objective is to maintain Black Rock reservoir contents at full capacity as much as possible by pumping when Columbia River water is available.
The monthly and seasonal instream flow objectives (cfs and acre-feet) are shown in Table 3.1 in the "Description of Operation Studies." As indicated in the "Operation Criteria" section (3.4.1.2), the sources of the water supply delivered to the exchange participants (Roza and Sunnyside) in the two Black Rock operations are different. When the April 1 TWSA is 3.2 million acre-feet and greater, Yakima River flows in excess of those shown in Table 3.13 can be diverted at Sunnyside Diversion Dam and the residual water supply for Sunnyside is delivered from Black Rock reservoir. However, when the April 1 TWSA is less than 3.2 million acre-feet, all of Sunnyside's water supply is delivered from Black Rock reservoir.

Table 3.14 shows the minimum and maximum Black Rock reservoir water deliveries to Roza and Sunnyside in nonprorated water years. For the 25-year period of hydrologic record (1981-2005), the minimum delivery occurs in 1997 when the April 1 TWSA was about 4.5 million acre-feet. The maximum delivery occurs in 2004 when the April 1 TWSA is about 2.6 million acre-feet. In 9 years of the 25-year period, the Yakima River excess flows were adequate to meet only some of Sunnyside's irrigation needs for one month or more. However, in 1997, Sunnyside's entire April and May irrigation needs could be met by Yakima River diversions. This Black Rock Alternative operation reduces the volume of Columbia River pumping to Black Rock reservoir by about one million acre-feet during the 25 years.

Black Rock reservoir contents are at the minimum level not later than the end of March prior to the start of the Yakima Project irrigation season. Minimum reservoir contents occur at the end of August because of the restriction on July and August pumping from the Columbia River. Maximum pumping to refill Black Rock storage space generally occurs in September and October. End-of-month Black Rock reservoir contents (maximum, minimum, average, and average percent of full) for the 25-year period of operation are shown in Table 3.15.

Table 3.12 Black Rock pumping volumes (acre-feet) for the 25-year period of record (1981-2005) (results from the Yak-RW Model)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	132,420	6,240	6,020	7,660	0	0	208,260	No pumping per Columbia River Basin Water Management Program	No pumping per Columbia River Basin Water Management Program	208,260	215,210	784,070
1982	0	21,310	6,240	6,020	7,660	30,520	88,760	68,390			208,260	148,130	585,290
1983	0	12,730	6,240	6,020	7,660	21,420	86,800	82,050			208,260	161,170	592,350
1984	6,480	6,250	6,240	6,250	7,720	56,320	0	178,250			208,260	149,160	624,930
1985	6,460	6,240	6,240	6,020	7,660	46,020	120,880	0			208,260	215,210	622,990
1986	81,950	0	12,490	6,020	7,660	69,100	0	207,460			208,260	182,150	775,090
1987	0	0	18,970	6,020	7,660	0	0	0			208,260	215,210	456,120
1988	0	0	0	0	0	0	0	0			208,260	215,210	423,470
1989	0	0	215,210	0	207,000	134,010	97,820	0			208,260	215,210	1,077,510
1990	0	88,180	6,240	6,020	7,660	39,840	0	207,460			208,260	177,300	740,960
1991	6,480	6,250	6,240	6,020	7,660	0	166,810	109,930			208,260	182,150	699,800
1992	0	0	0	25,220	7,720	0	0	0			208,260	215,210	456,410
1993	0	0	0	0	0	0	0	0			208,260	215,210	423,470
1994	0	0	215,210	0	0	0	0	0			208,260	215,210	638,680
1995	0	0	215,210	194,380	62,160	30,520	136,360	0			208,260	215,210	1,062,100
1996	81,960	6,250	6,240	6,250	7,720	33,320	93,500	108,280			208,260	179,120	730,900
1997	0	12,700	6,240	6,020	7,660	33,290	45,530	59,090			208,260	99,260	478,050
1998	6,480	6,250	6,240	6,020	7,660	0	110,950	87,380			208,260	179,370	618,610
1999	6,480	6,250	6,240	6,020	7,660	29,100	86,100	58,470			208,260	94,070	508,650
2000	4,000	8,730	6,240	6,250	7,720	15,120	0	0			208,260	215,210	471,530
2001	169,100	6,240	6,240	6,020	7,660	0	0	0			208,260	215,210	618,730
2002	189,620	6,250	6,240	6,020	7,660	21,500	0	184,050			208,260	149,860	779,460
2003	0	0	0	24,990	7,660	30,520	0	0			208,260	215,210	486,640
2004	110,000	0	118,520	6,250	7,720	0	0	0			208,260	215,210	665,960
2005	50,000	202,160	6,240	6,020	7,660	0	0	0			208,260	215,210	695,550
Avg	28,760	21,128	35,568	14,155	16,906	23,624	41,340	62,363			208,260	188,587	640,693
Min	0	0	0	0	0	0	0	0			208,260	94,070	423,470
Max	189,620	202,160	215,210	194,380	207,000	134,010	166,810	208,260			208,260	215,210	1,077,510

Table 3.13. Operation criteria for flow objectives at the Parker gage

April 1 TWSA (maf)	Instream flow objectives (cfs)[1]						
	Apr	May	Jun	Jul	Aug	Sep	Oct
1.75 and less	300 all months						
1.80	1,500	2,000	1,000	700	300	300	300
2.00	2,000	3,000	1,700	1,000	500	500	500
2.65	2,400	3,000	1,900	1,200	1,100	1,100	1,100
2.90	2,700	3,500	2,700	1,300	1,300	1,300	1,300
3.20	4,200	4,200	4,100	1,400	1,300	1,300	1,300
5.00	4,200	4,200	4,100	1,400	1,300	1,300	1,300

[1] For the period of July through October, the flow at the Parker gage is the greater of the values shown or the Title XII target flow modified by the water conservation actions of the No Action Alternative.

Table 3.14. Sources of water supply of exchange participants for the Black Rock Alternative for the 25-year period of record (1981-2005) using nonprorated water years 1997 and 2004 as illustrations (results from the Yak-RW model)

	Yakima River	Black Rock reservoir	Total
	(acre-feet rounded for illustration)		
Water year 1997 (TWSA 4.63 maf)			
Roza Division	65,000	235,000	300,000
Sunnyside Division (with minimum from Black Rock)	222,000	138,000	360,000
Total	287,000	373,000	660,000
Water year 2004 (TWSA 2.64 maf)			
Roza Division	65,000	235,000	300,000
Sunnyside Division (with maximum from Black Rock)	0	360,000	360,000
Total	65,000	595,000	660,000

Table 3.15. Black Rock reservoir end-of-month contents (kaf) for the 25-year period of record (1981-2005) (results from the Yak-RW model)

	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Max	1,300	1,300	1,300	1,300	1,300	1,299	1,298	1,298	1,240	1,140	1,256	1,300
Min	838	832	1,041	1,035	1,045	974	879	772	659	541	662	845
Avg	1,206	1,221	1,250	1,258	1,267	1,229	1,182	1,146	1,036	919	1,037	1,181
Avg % full	93	94	96	97	97	95	91	88	80	71	80	91

Table 3.16 shows the Columbia River water available, water pumped to Black Rock reservoir, and Black Rock reservoir end-of-month contents for water years 1991 (preceding the 3-year dry cycle of 1992-1994) through 1995 (immediately following the dry years). This table indicates that Black Rock reservoir is full at the end of March 1992, and that there is no Columbia River water available for withdrawal on a continuous basis until January 1995, with the exception of September and October of 1992-1994, and January 1994. By the end of August 1994, Black Rock reservoir contents are at a 25-year low of 551,000 acre-feet, about 40 percent of the total active capacity.[27]

Table 3.16. Columbia River water available, water pumped to Black Rock reservoir, and Black Rock reservoir end-of-month contents (water years 1991-1995)

Water year	Monthly water volumes available for pumping from the Columbia River in the vicinity of Priest Rapids Dam (maf)											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	1.266	2.326	6.649	5.141	1.477	0	1.737	.305	0	0	1.311	1.593
1992	0	0	0	1.618	0.46	0	0	0	0	0	.481	1.649
1993	0	0	0	0	0	0	0	0	0	0	.637	1.475
1994	0	0	.399	0	0	0	0	0	0	0	.578	1.481
1995	0	0	.576	2.466	3.262	.156	.998	0	0	0	1.577	1.774
Water year	Monthly water volumes pumped to Black Rock reservoir from the Columbia River in the vicinity of Priest Rapids Dam (results from Yak-RW model (maf)											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	.006	.006	.006	.006	.007	0	.167	.110	0	0	.208	.182
1992	0	0	0	.025	.007	0	0	0	0	0	.208	.215
1993	0	0	0	0	0	0	0	0	0	0	.208	.215
1994	0	0	.215	0	0	0	0	0	0	0	.208	.215
1995	0	0	.215	.194	.062	.030	.136	0	0	0	.208	.215
Water year	End-of-month reservoir contents (results from Yak-RW model (maf)											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	Full	Full	Full	Full	Full	1.228	1.297	1.296	1.175	1.055	1.171	Full
1992	1.293	1.287	1.281	Full	Full	1.228	1.131	1.022	.902	.785	.907	1.090
1993	1.083	1.077	1.071	1.065	1.057	.986	.889	.781	.667	.554	.679	.862
1994	.856	.850	1.059	1.053	1.045	.974	.879	.772	.661	.551	.677	.860
1995	.854	.848	1.057	1.245	Full	1.259	1.297	1.187	1.066	.946	1.062	1.224

It should be noted that, in addition to this dry-cycle, there are other months during the irrigation season of the 25-year hydrologic period (1981-2005) when there is no Columbia River water available for pumping in excess of the instream target flows.

[27] The 25-year minimum reservoir contents occur in August 1988 with 541,000 acre-feet.

3.4.1.3.2 Yakima Project Reservoirs

With the Black Rock Alternative, the ruleset for filling Yakima Project reservoirs remains the same as described in section 2.1.7. However, in regard to reservoir releases, the following changes are made:

1. From mid-October through May, additional releases of 185-200 cfs are made from Cle Elum Lake to increase Cle Elum River flows from the current 200 cfs to about 400 cfs.

   To lessen the effect of the September flip-flop, the transition of reservoir releases from the Yakima River to the Naches River were changed to begin on August 12 instead of August 31. The amount initially drafted from the Cle Elum Lake from April through August was reduced by 10 percent. Also, the fall use of Kachess Lake was reduced by about 300 cfs.

2. Enhanced instream flows at the Parker gage are based on the instream flow objectives suggested by the SSTWG (see Table 3.1). The criteria inputted to the Yak-RW model for operation of the Black Rock Alternative appears in Table 3.13. The flow at Parker when the April 1 TWSA estimate is 2.90 million acre-feet is similar to the SSTWG target flow for an average water supply year. This criteria requires the release of stored water (or bypass of reservoir inflow that would have been stored) in the spring to considerably improve flows at the Parker gage beyond the unregulated flow of the No Action Alternative. This operation is made possible as the result of the summer exchange, whereby a major portion of the stored water required is delivered to Roza and Sunnyside from Black Rock reservoir rather than from Yakima Project reservoirs.

3. The water exchange with Roza and Sunnyside is limited by their irrigation diversion demands. The disposition of the exchange water is dependent on whether the Yakima Project is in the pre-or post-storage control operation. In the first part of the irrigation season prior to storage control (generally April–June), when the Black Rock Alternative operation criteria calls for significant flows downstream from Parker, the water acquired from the exchange operation, together with stored water releases (or bypass of reservoir inflow which would have been stored), is added to the unregulated flow to increase the flow at Parker. Once storage control begins, a portion of the water acquired from the exchange is used to meet the Black Rock Alternative operation criteria for the Parker flow objectives. This is determined by taking into account the monthly Title XII target flow requirements at the Parker gage as increased by the

water conservation actions of the No Action Alternative. For instance, if the Black Rock Alternative operation criteria calls for a flow at the Parker gage of 1,300 cfs, the amount of this flow that is met from the water exchange is 1,300 cfs, less the Title XII target flows (as increased by the water conservation actions of the No Action Alternative). The residual amount accruing from the exchange remains in the Yakima Project storage system as potential carryover for the next year spring operation.

3.4.1.4 Municipal Operations

The municipal water supply operations are discussed in section 3.5. The additional municipal supply is provided during the entire water year.

3.4.1.5 Summary of Operations

Table 3.17 illustrates the primary operation criteria of the Yakima Project with the integration of the Black Rock Alternative.

Table 3.17. Yakima Project operation criteria with integration of Black Rock Alternative

End of prior calendar year		Current calendar year											
Prior irrigation season							Irrigation season						
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
		Filling Black Rock reservoir										Filling Black Rock reservoir	
Additional Cle Elum Lake releases of 185-200 cfs													
							Yakima Project irrigation diversions						
							Black Rock reservoir exchange deliveries to Roza and Sunnyside						
							Enhanced Parker gage flows based on TWSA estimates						
Municipal water diversions													

3.4.1.6 Hydrologic Indicators

The changes in the hydrologic indicators which occur with the Black Rock Alternative are shown in Table 3.18.

Table 3.19 shows the changes in the irrigation proration level with the Black Rock Alternative (both Black Rock 1 and Black Rock 2 are identical).

Table 3.18. Changes in hydrologic indicators under the Black Rock Alternative compared to the No Action Alternative for the 25-year period of record (1981-2005) (changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA distribution			Apr-Sep Yakima River flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima flow volume at Parker gage	Apr-Sep diversion volume upstream of the Parker gage	Sep 30 reservoir contents change			
	(maf) and % change						Proration and % change
Average 1981-2005 (results from Yak-RW model)							
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Black Rock Alternative	2.90	0.98	1.47	0.43	1.22	0.02	
Change from No Action Alternative	0.06	0.36	-.44	0.13	0.36	-0.03	
% change	2%	58%	-23%	43%	42%	-60%	
Dry year 1994 (results from Yak-RW model)							
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Black Rock Alternative	1.94	0.58	1.32	0.04	0.65	0.12	70%
Change from No Action Alternative	0.19	0.33	-.10	-.03	0.34	-0.26	43%
% change	11%	132%	-7%	-43%	110%	-68%	

[1] The irrigation delivery volume shortage is the difference between a full delivery supply to the farm (represented by the median volume delivered in nonprorated years for the period of record of 1981-2005) and the volume delivered in a specific year.

Table 3.19. Irrigation proration level for the Black Rock Alternative compared to the No Action Alternative (results from Yak-RW model)

Water year	Irrigation proration-level (percent)		
	No Action Alternative	Black Rock Alternative	Difference
1987	69	82	13
1992	70	80	10
1993	57	73	16
1994	27	70	43
2001	44	70	26
2005	45	70	25

The April 1 TWSA estimate for the Black Rock Alternative indicates an increase of 60,000 acre-feet from the No Action Alternative. This increase is the result of the water exchange, whereby a sizeable irrigation demand of the Roza and Sunnyside Divisions is removed from the Yakima Project and met by the delivery of water stored in Black Rock reservoir. This results in improving the September 30 reservoir carryover and increasing the April 1 TWSA. It should be noted that the TWSA estimate does not include the sizeable volume of stored water in Black Rock reservoir. Further, the additional release of 185-200 cfs from Cle Elum Lake to improve the aquatic resources begins in September and continues through May. While some "backfilling" of the vacated storage space does occur, there is no Yakima Project storage downstream from Cle Elum Lake to capture these releases, so they continue downstream to the Columbia River confluence.

There is an increase in the April-September diversions associated with the future municipal water supply. On the other hand, there is a decrease in the irrigation diversions with the delivery of a major portion of the Roza and Sunnyside Divisions' water needs from Black Rock Reservoir in lieu of diverting from the Yakima River. The net effect is a Yakima River diversion decrease of 440,000 acre-feet upstream of Parker gage. Corresponding with this diversion decrease is an increase of flow downstream from the Parker gage. However, not all of the reduced diversions are used to meet Parker flows; some water is held as carryover to allow for improved water supply during dry years.

Integration of the Black Rock Alternative with the Yakima Project operations results in a significant increase in the April-September flow volume at the mouth of the Yakima River. This increase of 360,000 acre-feet is the result of the water exchange, which permits water that would have been diverted by Roza and Sunnyside to remain in the Yakima River.

The irrigation delivery volume shortage is reduced significantly with the Black Rock Alternative. Further, a 70-percent proratable water supply is provided in the third-year of the 1992-1994 dry-year cycle. The irrigation delivery volume shortage is reduced significantly with the Black Rock Alternative as a result of a more reliable dry-year irrigation water supply.

3.4.1.6.1 Net Change to Columbia River Flow Volume

The withdrawal of Columbia River water for pumping to Black Rock reservoir results in a depletion of the flow volume in the vicinity of Priest Rapids Dam. The water exchange in the Yakima River basin results in an increase in the instream flows downstream from the Parker gage and subsequently being discharged at the mouth of the Yakima River. This exchange results in both

positive and negative changes during the year to the Columbia River flow volume approximately 62 miles downstream from Priest Rapids Dam.

The Black Rock Alternative average monthly changes to the Columbia River at the mouth of the Yakima River, compared with the No Action Alternative, are shown in Table 3.20 for the 25-year period period of hydrologic record (1981-2005). As indicated, the net monthly changes range from positive volumes during the April-August portion of the irrigation season and negative values in September and October of the irrigation season. During 4 months of the nonirrigation season (November-February), there is a negative net flow volume change; in March the net change is positive. The annual average for the 25-year period is a negative net change of about 118,000 acre-feet.

Major pumping occurs in September and October to refill Black Rock reservoir following July and August when there is no pumping from the Columbia River. During September and October, the average monthly flow volume available is in the magnitude of 1.2 to 1.7 million acre-feet. The withdrawals during these months are about 17 percent (September) and 11 percent (October) of the flow volume available to withdraw. During July and August when no pumping is permitted (without appropriate mitigation), the net changes in Columbia River flow volume below the mouth of the Yakima River are additional volumes of 46,000 and 36,000 acre-feet, respectively.

Table 3.20. Average monthly volumes for the Black Rock Alternative compared to the No Action Alternative for the 25-year period of record (1981-2005) (acre-feet) (results from Yak-RW model)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total
	Yakima River at Kiona flow volume												
No Action	183,207	216,048	249004	275,085	320,946	262,135	204,532	182,505	97,882	73,780	79,753	109,075	2,253,950
Black Rock	203,072	228,224	264,405	282,337	333,475	327,815	326,841	255,363	138,265	104,217	109,464	132,893	2,706,371
Change	19,865	12,176	15,401	7,252	12,529	65,680	122,309	72,858	40,383	30,437	29,711	23,818	452,421
Columbia River pumped volume to Black Rock reservoir less seepage return													
CR Pump[28]	22,990	15,168	29,607	8,719	10,944	17,854	35,379	56,592	-5,960[29]	-5,960	202,490	182,620	570,443
Net change to Columbia River below Yakima River confluence													
Net Change	-3,125	-2,992	-14,206	-1,467	1,585	47,826	86,930	16,266	46,343	36,397	-172,779	-158,802	-118,802
Columbia River water available for withdrawal													
CR Water Available	468,000	1,401,000	3,141,000	2,123,000	2,014,000	377,000	1,117,000	1,960,000			1,162,000	1,680,000	15,384,000
Percent of water pumped to water available and net change to water available													
% Pumped to Available	5%	1%	0.1%	0.4%	0.5%	5%	3%	3%			17%	11%	4%
% Net Change to Available	-0.6%	-0.2%	-0.4%	-0.07%	.07%	13%	8%	8%			-15%	-11%	-0.8%

[28] Pumping from Columbia River to Black Rock reservoir, less seepage back to Columbia River.

[29] There is no Columbia River pumping in July and August. Negative values represent reservoir seepage back to Columbia River.

3.4.2 Wymer Dam and Reservoir Alternative

The Wymer Dam and Reservoir Alternative integrates 162,500 acre-feet of new active storage capacity into the Yakima Project, increasing the total active storage capacity from 1,070,700 acre-feet to 1,233,200 acre-feet.[30] The new Wymer dam and reservoir would be an off-channel facility located about 8 miles upstream of Roza Diversion Dam on Lmuma Creek, an intermittent tributary.

The water supply for Wymer reservoir would be obtained by pumping from the Yakima River. A portion of the stored water (82,500 acre-feet) would be released each year in July and August for downstream irrigation use and for instream flows. The residual stored water (80,000 acre-feet) is for use only in dry years when the proration level is less than 70 percent.

3.4.2.1 Overview of Facilities and Operations

The Wymer Dam and Reservoir Alternative involves the construction of a concrete-faced embankment dam on Lmuma Creek, an intermittent tributary entering the Yakima River from the east. The dam would be approximately 450 feet high, creating a 162,500-acre-foot-capacity reservoir extending from about 1/4-mile east of the Yakima River to Interstate 82. A 180-foot-high central-core dike would also be constructed in a saddle on the north side of the reservoir.

The pumping plant, situated adjacent to the Yakima River (RM 135.0), would have a capacity of about 400 cfs with a head range of 365 to 475 feet. The reservoir outlet capacity would be 1,100 cfs.

For operational purposes, Wymer reservoir storage is divided into two components—(1) 82,500 acre-feet to be used annually to provide some of the water required during July and August for downstream irrigation demands and instream flows; and (2) 80,000 acre-feet to improve the proratable irrigation water supply for all Yakima Project proratable entitlements when the proration level is less than 70 percent.

3.4.2.2 Operation Criteria

Two operation studies have been conducted for the Wymer Dam and Reservoir Alternative—Options 1 and 2. Option 1 is based on the configuration of the facilities indicated above. Option 2 however, requires a larger pumping plant

[30] Wymer reservoir storage capacity would initially be about 168,076 acre-feet. However, about 6,612 acre-feet is associated with sediment deposition space that would eventually fill, leaving a residual of 162,564 acre-feet of active capacity.

capacity of about 1,250 cfs to fill Wymer reservoir. These options are explained below.

- The Option 1 operation uses additional October 1-May 31 releases from Cle Elum Lake of about 185-200 cfs to enhance Cle Elum River flows downstream, and to fill 82,500 acre-feet of the 162,500 acre-feet of Wymer reservoir capacity. The 82,500 acre-feet of stored water is released from Wymer reservoir in July and August to meet downstream irrigation demands and for Title XII target flows.

  The residual 80,000 acre-feet of Wymer reservoir capacity is filled by "skimming" Yakima River flows during January-March when they are in excess of 1,475 cfs. Wymer pumping plant capacity is about 400 cfs, and up to 200 cfs is used to fill the 82,500-acre-foot Wymer reservoir storage space, leaving a residual pumping capacity of 200 cfs to fill the remaining 80,000 acre-feet of storage space. The water stored in this 80,000 acre-feet of reservoir space is used only in dry years when the proration level is less than 70 percent.

- The Option 2 operation does not have the additional Cle Elum Lake winter and spring release operation. The first fill is 82,500 acre-feet of storage space which is done by skimming Yakima River flows in excess of 1,475 cfs from mid-October through March 31. This water is released in April through September to improve flows downstream from Parker. The extent of the releases are determined based on April 1 TWSA estimates of volumes available for instream flows.

  The 80,000 acre-feet is filled during January-March and is the smaller of:

  - The Wymer pumping plant capacity of 1,250 cfs, less the amount being pumped to the 82,500 acre-feet, or

  - Flows in excess of 1,475 cfs.

  The water stored in this capacity is used only in dry years when the proration level is less than 70 percent.

3.4.2.3 Reservoir Operations

3.4.2.3.1 Wymer Reservoir, Option 1

The additional October 1-May 31 Cle Elum Lake releases for the Option 1 operation (Table 3.21) are diverted at the Wymer pumping plant for storage in the 82,500-acre-foot storage space of Wymer reservoir. This stored water is released

in July and August. This operation decreases summer demands on Cle Elum Lake, reducing flows in the Yakima River at the Umtanum gage by an average of about 650 cfs. It also diminishes, to some extent, the flip-flop operation effects.

Table 3.21. Additional Cle Elum Lake releases pumped to the 82,500 acre-feet of Wymer reservoir active capacity for the 25-year period of record (1981-2005) for Option 1 (results from Yak-RW Model)[1]

Year	Nov	Dec	Jan	Feb	Mar	Apr	May		Oct	Total
	(acre-feet)									
1981	11,670	12,060	12,060	10,900	12,060	11,670	12,060		10,520	93,000
1982	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1983	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,480	82,450
1984	10,140	10,480	10,480	9,510	10,480	10,140	10,480		10,520	82,530
1985	10,190	10,320	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1986	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1987	10,190	10,520	10,520	9,510	10,520	10,190	10,520		0	71,970
1988	0	1,710	20	3,150	17,030	24,990	25,820		7,420	80,140
1989	10,620	10,980	10,980	9,920	10,980	10,620	10,980		6,940	82.020
1990	8,600	11,400	11,400	10,300	11,400	11,040	11,400		10,520	85.060
1991	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,480	82,400
1992	10,190	10,480	10,480	9,810	10,480	10,140	10,480		3,040	75,050
1993	7,030	6,510	4,660	10,320	10,910	19,690	20,350		0	79,470
1994	0	0	3,280	4,910	19,320	24,990	25,820		740	79,060
1995	11,230	12,010	12,010	10,850	12,010	11,630	12,010		10,480	92,230
1996	10,140	10,480	10,480	9,810	10,480	10,140	10,480		10,520	82,530
1997	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1998	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1999	10,190	10,520	10,520	9,510	10,520	10,190	10,520		5,810	77,780
2000	5,620	5,810	5,810	5,430	5,810	5,620	5,810		10,520	50,430
2001	10,190	10,520	10,520	9,510	10,520	10,190	10,520		1,200	73,170
2002	11,350	11,910	11,910	9,810	11,910	11,530	11,910		10,520	91,800
2003	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,480	82,450
2004	10,140	10,480	10,480	9,810	10,480	10,140	10,480		10,520	82,530
2005	10,190	10,520	10,520	9,810	10,520	10,190	10,520		3,200	75,170
Max	11,670	12,060	12,080	10,900	19,320	24,990	25,820		10,520	93,000
Min	0	0	20	3,150	5,810	5,620	5,810		0	50,430
Avg	9,158	9,622	9,612	9,196	11,184	11,785	12,173		7,860	80,590

[1] At times, due to unavailable inflow to Cle Elum Lake, the release of this additional instream flow may be delayed, resulting in shorter periods of higher releases not to exceed the 420-cfs pump capacity of Wymer pumping plant. An illustration of this is water year 1988 when higher releases occur in March, April, and May to make up for deficits in the prior months.

The Yakima River January-March flows in excess of 1,475 cfs and the volume pumped to the 80,000 acre-feet of Wymer reservoir storage space are shown in Table 3.22. This stored water is released only in dry years when the irrigation proration level is determined to be less than 70 percent.

Table 3.22. Yakima River volume available in excess of 1,475 cfs and volume pumped to the 80,000 acre-feet of Wymer reservoir active capacity for the 25-year period of record (1981-2005) for Option 1 (results from Yak-RW Model)

Year	Volume available				Volume pumped			
	Jan	Feb	Mar	Total	Jan	Feb	Mar	Total
	(acre-feet)							
1981	33,730	84,290	24,040	142,060	6,230	66,660	10,630	83,520
1982	29,480	103,980	65,860	199,320	5,430	11,150	15,300	31,880
1983	60,140	25,760	115,070	200,970	7,720	5,780	11,090	24,590
1984	116,320	32,170	87,210	235,700	Full	Full	Full	0
1985	0	0	1,300	1,300	0	0	0	0
1986	0	39,290	127,670	166,960	0	0	0	0
1987	0	0	36,520	36,520	0	0	0	0
1988	0	900	3,140	4,040	0	0	0	0
1989	2,700	3,550	7,830	14,080	0	0	0	0
1990	13,400	19,630	33,310	66,340	0	0	0	0
1991	97,320	82,660	56,600	236,580	0	0	0	0
1992	8,600	15,470	34,180	58,250	0	0	0	0
1993	0	0	12,610	12,610	0	0	0	0
1994	0	0	2,150	2,150	Full	Full	Full	0
1995	10,840	133,830	77,700	222,370	2,640	12,470	13,810	28,920
1996	218,810	330,810	212,480	762,100	13,340	14,350	15,340	43,030
1997	39,150	77,650	302,320	419,120	1,730	2,000	2,310	6,040
1998	3,370	19,350	72,660	95,380	Full	Full	Full	0
1999	52,470	5,260	57,330	115,060	0	0	0	0
2000	2,920	0	21,520	24,440	0	0	0	0
2001	0	0	810	810	Full	Full	Full	0
2002	9,550	7,020	6,820	23,390	4,320	3,220	5,140	12,680
2003	19,290	45,580	65,740	111,339	3,120	11,360	11,770	26,250
2004	950	2,250	52,550	55,750	890	1,800	12,550	15,240
2005	24,950	60	0	25,010	5,120	60	0	5,180
Max	218,810	330,810	302,320	762,100	13,340	66,660	15,340	83,520
Min	0	0	0	810	0	0	0	0

3.4.2.3.2 Wymer Reservoir, Option 2

Yakima River flows available in excess of 1,475 cfs during mid-October through March 31 to fill the Wymer reservoir active capacity of 162,500 acre-feet are shown in Table 3.23. Water is pumped to Wymer reservoir during this period to fill 82,500 acre-feet of the storage space each year (Table 3.24), and, to the extent possible, the 80,000 acre-feet of storage space during January through March (Table 3.25). The Option 2 operation requires a larger Wymer pumping plant of about 1,250-cfs capacity.

Table 3.23. Yakima River flows available for pumping into Wymer reservoir in excess of 1,475 cfs for the 25-year period of record (1981-2005), Option 2 (results from Yak-RW model)

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	110,760	33,730	84,290	24,040	0	0	0	0	0	0	0	252,820
1982	0	0	29,480	103,980	65,860	0	0	0	0	0	0	0	199,320
1983	0	330	68,850	25,030	137,850	0	0	0	0	0	0	0	232,060
1984	1,850	0	118,140	36,850	76,480	0	0	0	0	0	0	0	233,320
1985	0	0	0	0	1,300	0	0	0	0	0	0	80	1,380
1986	6,810	0	0	39,290	127,670	0	0	0	0	0	0	0	173,770
1987	13,620	0	0	0	36,520	0	0	0	0	0	0	0	50,140
1988	0	0	0	900	3,140	0	0	0	0	0	0	0	4,040
1989	610	3,100	2,710	3,560	7,830	0	0	0	0	0	0	0	17,810
1990	190	5,830	13,410	19,630	33,310	0	0	0	0	0	0	3270	75,640
1991	185,730	113,560	89,540	81,160	64,260	0	0	0	0	0	0	0	534,250
1992	0	11,080	10,000	23,190	34,180	0	0	0	0	0	0	0	78,450
1993	0	0	0	0	12,610	0	0	0	0	0	0	0	12,610
1994	0	0	0	0	2,140	0	0	0	0	0	0	0	2,140
1995	330	9,210	10,840	133,830	77,700	0	0	0	0	0	0	0	231,910
1996	118,610	190,400	222,800	333,880	225,230	0	0	0	0	0	0	0	1,090,920
1997	0	0	39,150	82,840	293,510	0	0	0	0	0	0	2,750	418,250
1998	8,290	520	6,710	19,490	65,680	0	0	0	0	0	0	0	100,690
1999	0	20,510	52,470	5,260	34,440	0	0	0	0	0	0	0	112,680
2000	72,770	138,880	3,270	0	21,520	0	0	0	0	0	0	0	236,440
2001	0	0	0	0	810	0	0	0	0	0	0	0	810
2002	570	330	9,520	7,010	6,810	0	0	0	0	0	0	0	24,240
2003	0	0	19,290	45,580	65,740	0	0	0	0	0	0	0	130,610
2004	3,090	380	940	2,250	52,540	0	0	0	0	0	0	0	59,200
2005	0	1,740	24,640	50	0	0	0	0	0	0	0	0	26,430
Avg	16,499	24,265	30,220	41,923	58,847	-	-	-	-	-	-	244	171,997
Min	-				-	-	-	-	-	-	-	-	810
Max	185,730	190,400	222,800	333,880	293,510	-	-	-	-	-	-	3,270	1,090,920

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Table 3.24. Yakima River flows pumped to Wymer 82,500-acre-foot pool for the 25-year period of record (1981-2005), Option 2 (results from the Yak-RW model)

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	38,560	23,280	20,660	0	0	0	0	0	0	0	0	82,500
1982	0	0	23,110	44,880	14,510	0	0	0	0	0	0	0	82,500
1983	0	330	46,150	23,160	12,860	0	0	0	0	0	0	0	82,500
1984	1,850	0	53,800	26,850	0	0	0	0	0	0	0	0	82,500
1985	0	0	0	0	1,300	0	0	0	0	0	0	80	1,380
1986	6,810	0	0	16,180	59,430	0	0	0	0	0	0	0	82,420
1987	13,620	0	0	0	35,540	0	0	0	0	0	0	0	49,160
1988	0	0	0	900	3140	0	0	0	0	0	0	0	4,040
1989	610	3,100	2,710	3,560	7830	0	0	0	0	0	0	0	17,810
1990	190	5,830	13,410	19,230	32,190	0	0	0	0	0	0	3270	74,120
1991	49,200	30,030	0	0	0	0	0	0	0	0	0	0	79,230
1992	0	11,080	8,960	21,250	34,180	0	0	0	0	0	0	0	75,470
1993	0	0	0	0	12,610	0	0	0	0	0	0	0	12,610
1994	0	0	0	0	2,150	0	0	0	0	0	0	0	2,150
1995	330	9,210	8,210	64,760	0	0	0	0	0	0	0	0	82,510
1996	51,560	30,940	0	0	0	0	0	0	0	0	0	0	82,500
1997	0	0	33,980	47,470	1,060	0	0	0	0	0	0	2750	85,260
1998	8,290	520	6710	19,490	42,160	0	0	0	0	0	0	0	77,170
1999	0	13,300	45,340	5,260	18,610	0	0	0	0	0	0	0	82,510
2000	46,760	35,740	0	0	0	0	0	0	0	0	0	0	82,500
2001	0	0	0	0	810	0	0	0	0	0	0	0	810
2002	570	330	9,520	7,010	6,810	0	0	0	0	0	0	0	24,240
2003	0	0	11,250	31,220	40,030	0	0	0	0	0	0	0	82,500
2004	3,090	380	940	2,250	52,510	0	0	0	0	0	0	0	59,170
2005	0	1740	22,480	50	0	0	0	0	0	0	0	0	24,270
Avg	7,315	7,244	12,394	14,167	15,109	-	-	-	-	-	-		56,473
Min	-	-	-	-	-	-	-	-	-	-	-	244 -	810
Max	51,560	38,560	53,800	64,760	59,430	-	-	-	-	-	-	3,270	85,260

Table 3.25. Yakima River flows pumped to Wymer 80,000-acre-foot pool for the 25-year period of record (1981-2005), Option 2 (results from Yak-RW model)

Water Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	0	5,820	16,330	24,000	0	0	0	0	0	0	0	46,150
1982	0	0	3,400	5,880	24,560	0	0	0	0	0	0	0	33,840
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	900	3,140	0	0	0	0	0	0	0	4,040
1989	0	0	2,710	3,560	7,830	0	0	0	0	0	0	0	14,100
1990	0	0	6,070	7,810	16,390	0	0	0	0	0	0	0	30,270
1991	0	0	31,610	0	0	0	0	0	0	0	0	0	31,610
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	11,490	0	0	0	0	0	0	0	11,490
1994	0	0	0	0	2,150	0	0	0	0	0	0	0	2,150
1995	0	0	1,890	4,660	65,170	0	0	0	0	0	0	0	71,720
1996	0	0	8,270	0	0	0	0	0	0	0	0	0	8,270
1997	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	7,710	6,540	6,810	0	0	0	0	0	0	0	21,060
2003	0	0	1,780	14,170	15,200	0	0	0	0	0	0	0	31,150
2004	0	0	940	2,250	8,240	0	0	0	0	0	0	0	11,430
2005	0	0	7340	50	0	0	0	0	0	0	0	0	7,390
Avg	-	-	3,102	2,486	7,399	-	-	-		-			12,987
Min	-	-	-	-	-	-	-	-	-	-	-	-	-
Max	-	-	31,610	16,330	65,170	-	-	-		-			71,720
									-	-	-		
									-	-	-		

Water stored in the 82,500 acre-feet of storage space is released April-September to improve instream flows at the Parker gage. The extent of the releases is the lesser of the following:

1. The amount necessary to get to the enhanced instream flow objectives using the same operation criteria as in the Black Rock Alternative (Table 3.13);

2. 1,100 cfs (Wymer reservoir outlet capacity); or

3. The volume of water remaining in the 82,500-acre-foot storage space.

Wymer reservoir end-of-month maximum, minimum, and average contents for the 25-year period of hydrologic record are shown in Table 3.26 for Option 1 and Table 3.27 for Option 2. On the average, the Option 1 operation results in higher end-of-month reservoir contents.

Table 3.26. End-of-month Wymer reservoir contents for the 25-year period of record (1981-2005), Option 1 (results from Yak-RW model [kaf])

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Storage	(162,500 acre-feet active reservoir capacity)											
Max	128.2	134.0	139.8	145.3	151.1	156.7	162.5	162.5	162.0	116.8	116.8	122.6
Min	0.0	0.0	3.3	8.2	27.5	52.5	78.3	78.3	39.2	0.0	0.0	0.0
Avg	74.7	84.3	96.0	107.9	123.0	134.0	145.2	144.0	106.6	59.6	57.8	65.6
Avg % full	46	52	59	66	76	82	89	89	66	37	36	40

Table 3.27. End-of-month Wymer reservoir contents for the 25-year period of record (1981-2005), Option 2 (results from Yak-RW model [kaf])

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct
Storage	(162,500 acre-foot active capacity reservoir)											
Max	126.8	162.5	162.5	162.5	162.5	162.5	162.5	147.0	132.5	104.7	80.0	82.7
Min	0.0	0.0	0.0	0.0	4.3	2.1	1.8	1.3	0.9	0.4	0.0	0.0
Avge	55.8	63.0	78.5	95.2	117.7	94.5	70.1	60.8	56.5	52.2	48.2	48.5
Avg % full	34	39	48	59	72	58	43	37	35	32	30	30

3.4.2.3.3 Yakima Project Reservoirs

Table 3.28 shows the modifications to the current Yakima Project operations with integration of either Option 1 or Option 2 of the Wymer Dam and Reservoir Alternative.

Table 3.28. Modifications to Yakima Project Operations with the Wymer Dam and Reservoir Alternative, for both Option 1 and Option 2

Yakima Project with Wymer Dam and Reservoir Alternative, Option 1	Yakima Project with Wymer Dam and Reservoir Alternative, Option 2
October 1-May 31—additional releases from Cle Elum Lake for improved habitat and for filling 82,500 acre-feet of Wymer reservoir storage space.	
Some of the irrigation demands and Title XII flows downstream from Wymer dam and reservoir are met by releasing the stored water in the 82,500 acre-feet of reservoir storage space during July and August. This permits decreasing releases from Cle Elum Lake and the flows in the Yakima River at the Umtanum gage to improve, to some extent, summer aquatic habitat conditions.	The capability to increase April-September flows at Parker in excess of the Title XII flows by releasing the stored water that is pumped to the 82,500 acre-feet of Wymer reservoir storage space.
January 1-March 31--"skimming operation" of Yakima River flows in excess of 1,475 cfs for storage in the 80,000 acre-feet of Wymer reservoir storage space to improve the proratable irrigation water supply when it is less than 70 percent.	October-March 31--"skimming operation" of Yakima River flows in excess of 1,475 cfs for storage in Wymer reservoir; 82,500 acre-feet of storage space is a first-fill priority while 80,000 acre-feet of storage space is filled to the extent possible during January 1 through March 31.
Flows downstream from Sunnyside Diversion Dam would be those associated with the Title XII target flows and the conservation actions flows of the No Action Alternative.	Flows downstream from Sunnyside Diversion Dam would be those associated with the Title XII target flows and the conservation actions flows of the No Action Alternative plus enhanced flows to the extent of available stored water in the 82,500 acre-feet of Wymer reservoir storage space.

3.4.2.4 Hydrologic Indicators

Table 3.29 provides the hydrologic indicators for Option 1 and Option 2 of the Wymer Dam and Reservoir Alternative.

Table 3.29. Hydrologic indicators for Wymer Option 1 and Wymer Option 2 (changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA Distribution			Apr-Sep Yakima Flow Volume at Mouth	Irrigation Delivery Volume Shortage[31]	Irrigation Proration Level
		Apr-Sep Yakima Flow Volume at Parker	Apr-Sep Diversion Volume upstream of Parker	Sep 30 Reservoir Contents Change			
	(maf) and % Change						Proration and % Change
Average 1981-2005 (Results from Yak-RW model)							
Wymer 1	2.94	0.59	1.95	0.40	0.83	0.05	
Wymer 2	2.95	0.67	1.94	0.34	0.90	0.05	
Change	0.01	0.08	0.01	-0.06	0.07	0.00	
Dry Year 1994							
Wymer 1	1.76	0.25	1.44	0.06	0.31	0.38	29%
Wymer 2	1.76	0.25	1.44	0.06	0.30	0.39	28%
Change	0.00	0.00	0.00	0.00	-0.01	0.01	-1%

Table 3.30 compares the end-of-irrigation-season proration level for the two options of the Wymer Dam and Reservoir Alternative.

Table 3.30. Change in end-of-season proration level with the Wymer Dam and Reservoir Alternative (Options 1 and 2) (results from the Yak-RW model)

Water year	End-of-season proration level (percent)				
	No Action	Option 1	Change with Option 1	Option 2	Change with Option 2
1987	69	73	4	76	7
1992	70	76	6	76	6
1993	57	68	11	63	6
1994	27	29	2	28	1
2001	44	59	15	52	8
2005	45	49	4	50	5

[31] The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record of 1981-2005) and the volume delivered in a specific year.

The major differences in flow volumes and proration levels for Wymer Option 1 and Wymer Option 2 are compared in Table 3.31.

Table 3.31. Differences in flow volumes and proration levels for Wymer Options 1 and 2 (results from Yak-RW model)

Alternative	April-September		July-September	
	Flow volume at Parker (average for the 25-year period, 1981-2005)			
	acre-feet	cfs	acre-feet	cfs
Wymer 1	590,000	1,625	130,000	712
Wymer 2	665,000	1,832	133,000	729
Difference with (Wymer 2)	75,000	207	3,000	17
Flow volume at mouth (average for the 25-year period, 1981-2005)				
Wymer 1	825,000	2,272		
Wymer 2	899,000	2,476		
Difference with (Wymer 2)	74,000	204		
Water year 1994 proration level (percent)				
Wymer 1	29%			
Wymer 2	28%			
Difference with (Wymer 2)	-1%			

Option 1 was selected for the Draft PR/EIS because of (1) a slight improvement in the proration level in the third year (1994) of the 3-year dry cycle, (2) improved flows in the Cle Elum River as the result of the additional winter-spring releases from Cle Elum Lake, and (3) the positive effect on the flip-flop operation brought about by the transfer of some of the stored water from Cle Elum Lake to Wymer reservoir for subsequent release for summer irrigation demands downstream from the Naches River confluence. Table 3.32 provides the hydrologic indicators and the changes from the No Action Alternative with the Wymer Dam and Reservoir Alternative, Option 1.

Table 3.32. Changes in hydrologic indicators under the Wymer Dam and Reservoir Alternative, Option 1, compared to the No Action Alternative for the 25-year period of record (1981-2005) (changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA Distribution			Apr-Sep Yakima River flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima flow volume at Parker gage	Apr-Sep diversion volume upstream of Parker gage	Sep 30 reservoir contents change			
	(maf) and % change						Proration and % change
Average 1981-2005 (results from Yak-RW model)							
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Wymer Dam and Reservoir Alternative	2.94	0.59	1.95	0.40	0.83	0.05	
Change from No Action Alternative	0.10	-0.03	0.04	0.10	-0.03	0.00	
%change	4%	-5%	2%	33%	-4%	0%	
Dry year 1994 (results from Yak-RW model)							
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Wymer Dam and Reservoir Alternative	1.76	0.25	1.44	0.06	0.31	0.38	29%
Change from No Action Alternative	0.01	0.00	0.02	-0.01	0.00	0.00	2%
% change	1%	0%	1%	-14%	0%	0%	

[1]The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record of 1981-2005) and the volume delivered in a specific year.

3.4.2.5 Municipal Operations

The municipal water supply operations are discussed in section 3.5. The additional municipal water supply is provided during the entire water year.

3.4.2.6 Summary of Operations

Table 3.33 illustrates the primary operation criteria of the Yakima Project with the integration of the Wymer Dam and Reservoir Alternative.

Table 3.33. Integrated Wymer Dam and Reservoir Alternative – Yakima Project operation criteria

<table>
<tr><td colspan="2">End of prior calendar year</td><td colspan="11">Current calendar year</td></tr>
<tr><td colspan="2">Prior irrigation season</td><td colspan="5"></td><td colspan="6">Irrigation season</td></tr>
<tr><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td></tr>
<tr><td></td><td colspan="6">Additional Cle Elum Lake releases of 185-200 cfs</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="6">Filling 82,500 acre-feet of Wymer reservoir</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Filling 80,000 acre-feet of Wymer reservoir (following dry years)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Yakima Project irrigation diversions</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Title XII instream flows with water conservation measures</td></tr>
<tr><td colspan="13">Municipal water diversions</td></tr>
</table>

3.4.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

3.4.3.1 Facilities

This alternative combines the Wymer Dam and Reservoir Alternative, Option 1, with a pumping plant near the mouth of the Yakima River and pipeline extending upstream delivering water to exchange for current Yakima River diversions. The Wymer dam and reservoir portion of this alternative is the same as described in section 3.4.2 with a pumping plant capacity of about 420 cfs and reservoir outlet capacity of 1,100 cfs.

The pump exchange aspect of this alternative involves a “bucket-for bucket” water exchange of up to 1,050 cfs with Roza and Sunnyside. This exchange allows a potion of water that would have been diverted to remain in the Yakima River to improve aquatic habitat.

3.4.3.2 Overview of Facilities and Operations

Two Yakima River Pump Exchange plans were developed, both with three pumping plants and buried pipelines. The delivery capacities of the facility plan

descriptions discussed below were based on an exchange of up to 1,200 cfs.[32] However, a more recent operation study indicated that the maximum exchange should not exceed 1,050 cfs to assure that the "bucket-for bucket" exchange is maintained.

Plan 1 involves only the Sunnyside Division and delivers 1,200 cfs to the Sunnyside Main Canal, completely replacing the Sunnyside Valley Irrigation District's (SVID) diversion from the Yakima River at Sunnyside Dam. A 750-cfs delivery would be made near the headworks at MP 2.35, and two other deliveries would be made lower on the canal—400 cfs at MP 37.0 and 50 cfs at the reregulation reservoir near the end of the canal at MP 59.29. The intermediate deliveries are planned to achieve minimum operating flow requirements in the canal.

Plan 2 splits the deliveries between Sunnyside and Roza, with 650 cfs delivered to the Sunnyside Main Canal and 550 cfs to the Roza Main Canal. In Plan 2, deliveries would not be made at the head of the Sunnyside Main Canal, which would save a substantial length of pipe. Rather, deliveries would be made at three locations—200 cfs at MP 30.0, 400 cfs at MP 37.0, and 50 cfs at MP 59.29. A delivery of 550 cfs will be made to the Roza Main Canal at one location, MP 59.0. The division of flow between Sunnyside and Roza could be adjustable.

Table 3.34 shows the components of Plan 2, which was the plan brought forward into the Draft PR/EIS.

3.4.3.3 Operation Criteria

3.4.3.3.1 Wymer Reservoir

Storage in the 162,500-acre-foot active capacity Wymer reservoir is segregated into two volumes (82,500 acre-feet and 80,000 acre-feet) and is filled and released as described in the Wymer Dam and Reservoir Alternative, Option 1.

3.4.3.3.2 Yakima River Pump Exchange

Plan 2, which was used in the Draft PR/EIS, involves a potential water exchange with both Roza and Sunnyside. The pump exchange operation is based on replacing, on a daily basis, a portion of the Yakima River flow that would be diverted by Roza and Sunnyside with water pumped from near the mouth and delivered into the Roza and Sunnyside Canals. The pump exchange would begin when water is first diverted about mid-March for priming of the canals and

[32]The pump exchange facilities are described in the *Appraisal Assessment of the Yakima River Pump Exchange Alternative Delivery System for Roza and Sunnyside Valley Irrigation Districts* (Reclamation, 2006).

continue throughout the irrigation season. The water not diverted remains in the Yakima River for instream flow purposes downstream from the current points of diversion to its confluence with the Columbia River.

Table 3.34. Design components of the Yakima River pump exchange

Item	Pumping plant #1	Pumping plant #2	Pumping plant #3
Location	By Columbia River, in Kennewick WA	Near Benton City WA	Near Sunnyside Canal (MP 37.0)
Inflow	1,200 cfs	1,200 cfs	1,150 cfs
Outflow capacity	1,200 cfs	1,200 cfs	550 cfs
Pumps and capacity	6 pumps at 200 cfs each*	6 pumps at 200 cfs each*	3 pumps at 183 cfs[1]
Lift	530 feet	270 feet	165 feet
Discharge to:	Outflow pipeline	Outflow pipeline	(see below)
Outflow pipeline (pumped water)			
Location	Pumping plant #1 to pumping plant #2	Pumping plant #2 to pumping plant #3, with 50 cfs discharge to Sunnyside Canal (MP 59.29)	Pumping plant #3 to Roza Canal (MP 59.0)
Capacity	1,200 cfs	1,200 cfs	550 cfs
Type	2 steel pipelines	2 steel pipelines	1 steel pipeline
Diameter	132-inch-diameter	132-inch-diameter	120-inch
Length	17 miles	31 miles	1 mile
Outflow pipeline (gravity-flow water)			
Location			Pumping plant #3 to Sunnyside Canal (MP 37.0)
Capacity			400 cfs
Type			1 steel pipeline
Diameter			84-inch
Length			2 miles
Location			Plant #3 to Sunnyside Canal (MP 30.0)
Capacity			200 cfs
Type			1 steel pipeline
Diameter			72-inch
Length			5 miles

[1] In addition, there is one standby pump at each pumping plant.

The pump exchange operation criteria has been established to increase flows downstream from Sunnyside Diversion Dam by 1,500 cfs through a combination

of the Title XII flows (and water conservation actions) and the pump exchange operation, while not depleting flows at the mouth of the Yakima River from those which occur with the No Action Alternative. This is with the exception of those depletions associated with the Cle Elum Lake-Wymer reservoir operations and Yakima River withdrawals for future additional municipal water supplies.

The pump exchange operation is based on the following water exchanges:

- Roza Division – The lesser of 550 cfs, or Roza Division's daily diversion demand minus 200 cfs.[33]
- Sunnyside Division – The lesser of 750[34] cfs or 1,200 cfs minus the Roza Division exchange, or Sunnyside Division's daily demand.

3.4.3.4 Yakima River Pump Exchange Operations

The monthly and seasonal instream flow objectives (cfs and acre-feet) are shown in Table 3.1 and Table 3.2 in the "Description of Operation Studies" section. The instream flow operation criteria for the Wymer Dam Plus Yakima River Pump Exchange Alternative is to provide 1,500 cfs during the irrigation season downstream from Sunnyside Diversion Dam to assist in meeting these instream flow objectives. In the first part of the irrigation season (generally April-June) prior to storage control, the pump exchange contributes to the unregulated flows (natural and return flows) at the Parker gage by allowing a portion of the flow which would have been diverted by Roza and Sunnyside to remain in the river. Once on storage control when there is little unregulated flow at the Parker gage, the pump exchange adds to the flow by the extent the Title XII instream target flows are less than 1,500 cfs.[35] This maintains a flow at Parker in the latter part of the irrigation season (generally July-October) of 1,500 cfs.

The maximum pump exchange is 1,050 cfs, which results from 1,500 cfs less the dry-year Title XII instream target flows (300 cfs) and the dry-year water

[33] The 200-cfs amount is the minimum "carriage flow" required for operation of the Roza Canal upstream of the pump exchange inflow point which is near MP 59.0.

[34] It was assumed in the modeling that the maximum pumping to Sunnyside was limited to 750 cfs. This does not match the final pump exchange plan, which now appears to deliver up to a maximum of 650 cfs to Sunnyside. Consequently, the exchange supply provided to Sunnyside may be slightly higher than is possible with the 650-cfs delivery capacity.

[35] These are the current Title XII instream target flows as increased by the water conservation actions of the No Action Alternative.

conservation action flows (150 cfs) at the Parker gage.[36] In wetter years, when the Title XII and water conservation action flows are greater, the pump exchange is at the minimum of about 650 cfs.

The first priority of the pump exchange is the 550 cfs to be delivered at Roza Canal MP 59.0. This is because Roza's current point of diversion is higher in the Yakima River system (RM 127.9) than Sunnyside's (RM 103.8), thus providing the maximum extent of improved streamflows in this 14.1-mile river reach.

The pump exchange with Sunnyside is contingent on the residual flow needed to meet the 1,500-cfs operation criteria. However, the exchange is limited by the pump exchange delivery capacity to Sunnyside (650 cfs) and cannot result in a flow at the mouth of the Yakima River that would have been less than would have occurred in the absence of the pump exchange (the No Action Alternative). When the Roza exchange is at its maximum, the exchange with Sunnyside is limited to 500 cfs.[37] However, Sunnyside's exchange may be as low as 100 cfs in wet years when maximizing the exchange with Roza.

The volume of water delivered to Roza and Sunnyside by means of the pump exchange and the residual volume diverted from the Yakima River is illustrated in Table 3.35 by two nonprorated water years—1997 (with a TWSA estimate of about 4.63 million acre-feet) and 2004 (with a TWSA estimate of 2.64 million acre-feet). As shown in the table, the water exchange to Roza in a nonprorated water year remains the same and the variance occurs in the pump exchange deliveries to Sunnyside.

The monthly water demands of Roza and Sunnyside and the sources of supply (diversion from the Yakima River and the pump exchange) for the 25-year period of record (1981-2005) from the Yak-RW model operation is included in the Appendix.

[36] The 150-cfs amount is comprised of the increased flow over Sunnyside Diversion Dam associated with the water conservation measures (136 cfs in a nonprorated year) and the operational flows related to changes in points of diversion from upstream to downstream of Sunnyside Diversion Dam (108 cfs in a nonprorated year). The 150-cfs amount is the prorated flow in the 1994 dry year.

[37] The 500-cfs amount is computed as 1,050 cfs less Roza's 550 cfs.

Table 3.35. Source of water supply of exchange participants for the Wymer Dam Plus Yakima River Pump Exchange Alternative for the 25-year period of record (1981-2005) (Results from Yak-RW model using nonprorated water years 1997 and 2004 as an illustration)

	Yakima River Pump Exchange	Yakima River	Total
	(acre-feet rounded for illustration)		
Water year 1997 (TWSA 4.63 maf)			
Roza Division	188,000	112,000	300,000
Sunnyside Division (with minimum from pump exchange)	75,000	285,000	360,000
Total	263,000	397,000	660,000
Water year 2004 (TWSA 2.64 maf)			
Roza Division	188,000	112,000	300,000
Sunnyside Division (with maximum from pump exchange)	194,000	166,000	360,000
Total	382,000	278,000	660,000

3.4.3.5 Modifications to Yakima Project Operations

The addition of the Wymer Dam Plus Yakima River Pump Exchange Alternative results in the following operational modifications to the Yakima Project:

- October 1-May 31 additional releases from Cle Elum Lake for improved aquatic habitat and for filling 82,500 acre-feet of Wymer reservoir storage capacity. This permits, to some extent, the subsequent "backfilling" of the vacated Cle Elum Lake storage space.

- The capability to meet some of the irrigation demands and Title XII flows downstream from Wymer dam and reservoir by releasing the stored water that was pumped to the 82,500 acre-feet of Wymer reservoir storage space.

- The January 1-March 31 "skimming operation" of Yakima River flows in excess of 1,475 cfs for storage in the 80,000 acre-feet of Wymer reservoir storage space for use in dry years to improve the proratable water supply when it is less than 70 percent.

Flows downstream from Sunnyside Diversion Dam would be the enhanced flows during the April-October irrigation season with the capability to deliver up to 1,050 cfs to Roza and Sunnyside by means of the Yakima River pump exchange.

3.4.3.6 Municipal Water Supply Operations

The municipal water supply operations are discussed in Section 3.5.

3.4.3.7 Summary

The primary operation criteria of an integrated Wymer Dam Plus Yakima River Pump Exchange Alternative are shown in Table 3.36.

Table 3.36. Integrated Wymer Dam Plus Yakima River Pump Exchange Alternative Yakima Project operation criteria

End of prior calendar year		Current calendar year											
Prior irrigation season							Irrigation season						
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Additional Cle Elum Lake releases of 185-200 cfs												
	Filling 82,500 acre-feet of Wymer reservoir												
				Filling 80,000 acre-feet of Wymer reservoir (following dry years)									
							Yakima Project irrigation diversions						
							Yakima River pump exchange deliveries to Roza and Sunnyside						
							Enhanced Parker gage flows						
Municipal water diversions													

3.4.3.8 Hydrologic Indicators

Table 3.37 shows the hydrologic indicator changes that occur when comparing the Wymer Dam Plus Yakima River Pump Exchange Alternative to the No Action Alternative.

The changes outlined in the table show an improvement in the Yakima Project water supply over the 25-year period of record. The primary reason for this improvement is the water exchange, whereby some of the current Yakima River irrigation diversions would be provided by pumping water from near the mouth of the Yakima River upstream for delivery to Sunnyside and Roza.

Table 3.37 Changes in hydrologic indicators under Wymer Dam Plus Yakima River Pump Exchange Alternative compared to the No Action Alternative for the 25-year period of record (1981-2005) (changes shown in absolute value and percent of change)

	Apr 1 TWSA	TWSA distribution			Apr-Sep Yakima River flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima River flow volume at Parker gage	Apr-Sep Diversion volume upstream of Parker gage	Sep 30 reservoir contents change			
	(maf) and % change						Proration and % change
Average 1981-2005 (results from Yak-RW model)							
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Wymer Dam Plus Yakima River Pump Exchange Alternative	2.94	0.90	1.64	0.40	0.83	0.05	
Change from No Action Alternative	0.10	0.28	-0.27	0.10	-0.03	0.00	
% change	4%	45%	-14%	33%	-3%	0%	
Dry year 1994 (results from Yak-RW model)							
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Wymer Dam Plus Yakima River Pump Exchange Alternative	1.77	0.57	1.13	0.06	0.31	0.38	29%
Change from No Action Alternative	0.02	0.32	-0.29	-0.01	0.00	0.00	2%
% change	1%	128%	-20%	-14%	0%	0%	

[1]The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record 1981-2005) and the volume delivered in a specific year.

Table 3.38 is the change in the proration levels with the Wymer Dam Plus Yakima River Pump Exchange Alternative when compared to the No Action Alternative. The proration levels are the same as the Wymer Dam and Reservoir Alternative.

Table 3.38. Irrigation proration level for the Wymer Dam Plus Yakima River Pump Exchange Alternative compared to the No Action Alternative (results from Yak-RW model)

Water year	No Action Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative	Difference
	Proration level (percent)		
1987	69	73	4
1992	70	76	6
1993	57	68	11
1994	27	29	2
2001	44	59	15
2005	45	49	4

3.5 Future Municipal Water Supply

Future municipal water supply needs are those within the Yakima River basin projected to year 2050 in addition to those estimated for year 2000. These future municipal needs represent the total requirements regardless of the water source. While groundwater is currently the preferred source because it requires less treatment than surface water, a conservative approach has been taken by assuming the total additional needs will be met by surface water.

Table 3.39 is information obtained from documents published as a part of the *Watershed Management Plan* activities conducted by the Yakima River Basin Planning Unit and the Tri-County Water Resources Agency (2003).

Table 3.39. Municipal and domestic water needs for years 2000, 2010, 2020, and 2050

	No. of services (in 1999)	Needs (acre-feet)			
		[1]2000	[1]2010	[1]2020	2050
Yakima River basin total	109,180	115,772	138,199	163,316	[2]215,000
Upper Yakima subarea					
Ellensburg	3,230	4,820	6,053	7,062	
Cle Elum	1,000	897	1,009	1,121	
Other community and Class B PWS	3,111	3,139	3,845	4,551	
Noncommunity	881	988	1,210	1,432	
Yakima Training Center	4	90	90	90	
Households with own well	5,602	5,652	6,924	8,195	
Total Upper Yakima	13,828	15,585	19,130	22,451	29,000
Middle Yakima subarea					
City of Yakima (potable supply)	16,756	17,151	18,384	19,393	
City of Yakima (irrigation supply)		Not available	2,242	2,242	
Nob Hill Water Association	7,595	3,811	4,708	5,717	
Selah	1,682	2,915	3,363	3,699	
Union Gap	1,200	1,211	1,398	1,586	
Terrace Heights	1,104	673	1009	1,223	
Other community and Class B PWS	3,489	3,520	4,066	4,611	
Noncommunity	154	173	199	226	
Yakima Training Center	109	90	90	90	
Households with own well	18,720	18,887	21,814	24,741	
Total Middle Yakima	50,809	48,430	57,274	63,539	70,000
Naches subarea					
Other community and Class B PWS	1,474	1,487	1,755	2,022	
Noncommunity	607	680	803	925	
Households with own well	2,575	2,598	3,066	3,533	
Total Naches	4,656	4,565	5,623	6,481	18,000
Lower Yakima subarea					
Sunnyside	2,956	3,252	3,399	4,260	
Grandview	2,300	3,139	4,148	5,381	
Toppenish	2,000	2,018	2,331	2,643	
Lower Yakima subarea (continued)					

	No. of services (in 1999)	Needs (acre-feet)			
		[1]2000	[1]2010	[1]2020	2050
Wapato	1,104	1,345	2,803	3,139	
Benton City	729	224	785	1,345	
Prosser	1,600	3,139	3,587	3,924	
Richland	5,451	9,192	9,753	15,358	
West Richland	2,200	2,915	3,924	6,278	
Other community and Class B PWS	6,777	6,837	7,897	8,957	
Noncommunity	272	305	353	399	
Households with own well	14,498	14,627	16,894	19,161	
Total Lower Yakima	39,887	46,992	56,172	70,844	[4]98,000
LESS: Richland and West Richland[3]	-7,561	-12,107	-13,677	-21,636	[5]-29,000
Adjusted lower basin	32,326	34,885	42,495	49,208	69,000
Yakima River basin groundwater and surface-water supply	101,619	103,465	124,522	141,679	186,000
Increase from year 2000			20,000	38,000	82,000

[1] From table 6 of the *Municipal, Domestic, and Industrial Water Needs and Supply Strategies,* January 2002, Technical Memorandum prepared by Economics and Engineering Services. This is consistent with table 2-1 of the January 6, 2003, *Watershed Management Plan.*

[2] From exhibit 2-2 of the W*ater Management Plan*.

[3] Water system plans provide for joint development of Columbia River surface supply.

[4] Page 3-6 of the January 6, 2003, *Water Management Plan* provides information on the extent of increased needs in the upper Yakima, middle Yakima, and Naches subareas from year 2000 to year 2050. These increased needs were added to the respective subareas' year 2000 use to provide a year 2050 total of 117,000 acre-feet for the three subareas. The 117,000 acre-feet was subtracted from the Yakima River basin total need of 215,000 acre-feet, providing a figure of 98,000 acre-feet for the lower Yakima subarea.

[5] The year 2020 need of the cities of Richland and West Richland is 30 percent of the lower Yakima subarea year 2020 estimated need. The 30-percent figure was applied to the lower Yakima subarea year 2050 need of 98,000 acre-feet, resulting in a year 2050 estimated need of 29,000 acre-feet for these two cities.

The distribution of the year 2050 additional future municipal need of 82,000 acre-feet among the four Yakima River Basin subareas and the water supply criteria is shown in Table 3.40.

Table 3.40. Distribution of municipal needs by subareas and water supply criteria

Subarea	Municipal Need 2050	Water Supply Criteria
Upper Yakima	13,000	Storage releases during storage control and unregulated flows during the residual period
Middle Yakima and Naches	35,000	
Lower Yakima	34,000	Return flows
Total	82,000	

In the Joint Alternatives' operation studies, the municipal water supply to meet these needs is modeled as a continuous flow withdrawal at selected diversion points in the subarea. It is assumed that 50 percent of this withdrawal returns as surface and subsurface flows. The future municipal water supply is assumed to be a proratable water supply. Table 3.41 shows the average annual volume of municipal water supply provided by each Joint Alternative in year 2050.

Table 3.41. Average annual municipal water supply provided for the 25-year period of record (1991-2005) (results from Yak-RW model)

Alternative	Average Annual Supply (acre-feet)`
Black Rock Alternative	81,100
Wymer Dam and Reservoir Alternative	79,800
Wymer Dam Plus Yakima River Pump Exchange Alternative	79,800

As noted in the operation criteria, the municipal water supply is a junior (proratable) supply. Table 3.42 shows the municipal water supply available for each Joint Alternative in the 6 dry years when proration was necessary.

Table 3.42. Municipal water available in dry years (results from Yak-RW model)

Water year	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative	Black Rock Alternative
	(acre-feet)		
1987	78,000	78,000	80,000
1992	78,000	78,000	80,000
1993	77,000	77,000	79,000
1994	68,000	68,000	79,000
2001	75,000	75,000	78,000
2005	71,000	71,000	78,000

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APPENDIX

Summary Tables

Table 1. Summary of hydrologic indicators absolute values (Average 1985-2005 and Dry-Year 1994)

Table 2. Yak-RW annual output for the 25-year period of record (1981-2005) for Current Operation

Table 3. Yak-RW annual output for the 25-year period of record (1981-2005) for the No Action Alternative

Table 4. Yak-RW annual output for the 25-year period of record (1981-2005) for Wymer Dam and Reservoir Alternative, Option 1

Table 5. Yak-RW annual output for the 25-year period of record (1981-2005) for Wymer Dam and Reservoir Alternative, Option 2

Table 6. Yak-RW annual output for the 25-year period of record (1981-2005) for the Wymer Dam Plus Yakima River Pump Exchange Alternative

Table 7. Yak -RW annual output for the 25-year period of record (1981-2005) for the Black Rock Alternative, Option 1

Table 8. Yak -RW annual output for the 25-year period of record (1981-2005) for the Black Rock Alternative, Option 2

Table 9. Reasons for hydrologic indicators—changes from the No Action Alternative

Table 1. Summary of hydrologic indicators absolute values (Average 1985-2005 and Dry-Year 1994)

Hydrology Indicators	Alternatives							
	Current Condition	No Action	No Action + New M&I	Alt 1a - Wymer Only 1	Alt 1b - Wymer Only 2	Alt 2 - Wymer Plus	Alt 3a - Black Rock 1	Alt 3b - Black Rock 2
Average 1981-2005	Units (maf) unless otherwise noted							
TWSA (Available Volume above Parker) Apr -Sep	2.82	2.84	2.83	2.94	2.95	2.94	2.90	2.90
Components								
Runoff Volume Apr-Sep	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
Return Flow Volume Apr-Sep	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Total Yakima Reservoir Contents Mar 31	0.60	0.62	0.62	0.72	0.74	0.73	0.68	0.68
Total Yakima Reservoir Contents June 30	0.91 (85% Full)	0.92 (87% Full)	0.92 (86% Full)	1.05 (85% Full)	0.99 (81% Full)	1.05 (85% Full)	0.91 (85% Full)	0.91 (85% Full)
Bumping (Capacity 0.0337)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Cle Elum (Capacity 0.4369)	0.35	0.36	0.36	0.33	0.36	0.33	0.34	0.34
Kachess (Capacity 0.239)	0.22	0.22	0.22	0.22	0.22	0.23	0.24	0.24
Keechelus (Capacity 0.1578)	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Rimrock (Capacity *0.198)*	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.18
Wymer (Capacity 0.162)	NA	NA	NA	0.15	0.07	0.15	NA	NA
Distribution								2.89
Flow Volume past Parker Apr-Sep	0.51	0.62	0.61	0.59	0.67	0.90	1.02	0.98
Flow Volume past Parker July-Sept (Average Flow)	0.09 (470 cfs)	0.13 (720 cfs)	0.13 (710 cfs)	0.13 (710 cfs)	0.13 (730 cfs)	0.29 (1580 cfs)	0.24 (1320 cfs)	0.23 (1260 cfs)
Total Yakima Reservoir Contents Sept 30	0.27	0.30	0.29	0.40	0.34	0.40	0.43	0.43
Total Diversion Volume above Parker (WSAI) Apr-Sep	2.02	1.91	1.93	1.95	1.94	1.64	1.43	1.47
Nonproratable Diversion Apr-Sep (Entitlements 1.10)	0.99	0.94	0.94	0.94	0.94	0.77	0.77	0.77
Proratable Diversion Apr-Sep (Entitlements 1.24)	1.03	0.97	0.99	1.01	1.00	0.87	0.66	0.70
End of Season Proration %	85%	86%	86%	88%	88%	88%	93%	93%
Black Rock Contents March 31 (Capacity 1.3)	NA	NA	NA	NA	NA	NA	1.27	1.27
Black Rock Diversion Apr-Sep	NA	NA	NA	NA	NA	NA	0.54	0.50
Available Volume below Parker Apr-Sep	1.02	1.05	1.06	1.04	1.11	1.35	1.47	1.43
Components								
Flow Volume past Parker Apr-Sep	0.51	0.62	0.61	0.59	0.67	0.90	1.02	0.98
Runoff Volume Apr-Sep	0.31	0.*31*	*0.31*	*0.31*	0.31	0.31	0.31	0.31
Return Flow Volume Apr-Sep	0.20	0.13	0.13	0.13	0.13	0.13	0.14	0.14
Distribution								
Flow Volume at Mouth Apr-Sep	0.85	0.86	0.84	0.83	0.90	0.83	1.26	1.22
Total Diversion Volume below Parker Apr-Sep	0.17	0.19	0.21	0.21	0.21	0.52 (0.31 Exch)	0.21	0.21
Delivery Shortage Apr-Sep	-0.07	-0.05	-0.06	-0.05	-0.05	-0.05	-0.02	-0.02
Dry Year 1994								
TWSA (Available Volume above Parker) Apr -Sep	1.75	1.75	1.75	1.76	1.76	1.77	1.94	1.94
Components								
Runoff Volume Apr-Sep	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39
Return Flow Volume Apr-Sep	0.16	0.16	0.16	0.16	0.16	0.16	0.19	0.19
Total Yakima Reservoir Contents Mar 31	0.21	0.20	0.20	0.22	0.21	0.22	0.36	0.36
Total Yakima Reservoir Contents June 30	0.56 (85% Full)	0.56 (87% Full)	0.56 (86% Full)	0.58 (85% Full)	0.57 (81% Full)	0.58 (85% Full)	0.53 (85% Full)	0.53 (85% Full)
Bumping (Capacity 0.0337)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Cle Elum (Capacity 0.4369)	0.21	0.21	0.21	0.13	0.21	0.13	0.10	0.10
Kachess (Capacity 0.239)	0.12	0.12	0.12	0.12	0.12	0.13	0.24	0.24
Keechelus (Capacity 0.1578)	0.06	0.06	0.06	0.06	0.06	0.06	0.02	0.02
Rimrock (Capacity 0.198)	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15
Wymer (Capacity 0.16)	NA	NA	NA	0.09	0.01	0.09	NA	NA
Distribution								1.94
Flow Volume past Parker Apr-Sep	0.19	0.25	0.25	0.25	0.25	0.57	0.58	0.58
Flow Volume past Parker July-Sept (Average Flow)	0.06 (310 cfs)	0.08 (470 cfs)	0.08 (460 cfs)	0.09 (470 cfs)	0.08 (470 cfs)	0.24 (1320 cfs)	0.13 (690 cfs)	0.13 (690 cfs)
Total Yakima Reservoir Contents Sept 30	0.07	0.07	0.06	0.06	0.06	0.06	0.04	0.04
Total Diversion Volume above Parker (WSAI) Apr-Sep	1.49	1.42	1.43	1.44	1.44	1.13	1.32	1.32
Nonproratable Diversion Apr-Sep (Entitlements 1.10)	0.99	0.94	0.94	0.94	0.94	0.77	0.77	0.77
Proratable Diversion Apr-Sep (Entitlements 1.24)	0.50	0.48	0.49	0.50	0.50	0.36	0.55	0.55
End of Season Proration %	28%	27%	28%	29%	28%	29%	70%	70%
Black Rock Contents March 31 (Capacity 1.3)	NA	NA	NA	NA	NA	NA	1.05	1.05
Black Rock Diversion Apr-Sep	NA	NA	NA	NA	NA	NA	0.52	0.52
Available Volume below Parker Apr-Sep	0.47	0.49	0.50	0.50	0.50	0.82	0.85	0.85
Components								
Flow Volume past Parker Apr-Sep	0.19	0.25	0.25	0.25	0.25	0.57	0.58	0.58
Runoff Volume Apr-Sep	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Return Flow Volume Apr-Sep	0.14	0.09	0.10	0.10	0.10	0.10	0.12	0.12
Distribution								
Flow Volume at Mouth Apr-Sep	0.32	0.31	0.30	0.31	0.30	0.31	0.65	0.65
Total Diversion Volume below Parker Apr-Sep	0.15	0.18	0.19	0.19	0.19	0.51 (0.32 Exch)	0.20	0.20
Delivery Shortage Apr-Sep	-0.40	-0.38	-0.39	-0.38	-0.39	-0.38	-0.12	-0.12

Table 2. Yak-RW annual output for the 25-year period of record (1981-2005) for Current Operation (all units are acre-feet unless otherwise noted)

Water year	TWSA (available volume above Parker) Apr -Sep	Components			Approximate Maximum Storage							Distribution							Columbia River available	Black Rock contents Mar 31 (capacity 1.3)	Black Rock diversion	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return flow volume Apr-Sep	Total Yakima reservoir contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.16)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (average flow)	Total Yakima reservoir contents Sep 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonprorat -able diversion Apr-Sep (entitle- ments 1.10)	Prorat- able diversion Apr-Sep (entitle- ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,501,000	1,429,980	222,020	849,000	922,000	33,000	309,000	239,000	143,000	198,000	NA	162,590	55,250	185,000	2,129,830	990,000	1,139,830	93%	NA	NA	NA	607,400	162,590	245,520	199,290	448,710	158,690	NA	3,000
1982	3,411,500	2,593,270	223,230	595,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	783,290	132,750	457,000	2,138,240	990,000	1,148,240	100%	NA	NA	NA	1,424,790	783,290	430,870	210,630	1,262,170	162,620	NA	0
1983	3,374,500	2,355,890	222,610	796,000	1,016,000	33,000	437,000	239,000	109,000	198,000	NA	785,670	112,000	417,000	2,138,470	990,000	1,148,470	100%	NA	NA	NA	1,516,900	785,670	523,060	208,170	1,359,160	157,740	NA	0
1984	3,271,300	2,231,520	224,780	815,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	636,430	143,260	462,000	2,138,410	990,000	1,148,410	100%	NA	NA	NA	1,192,710	636,430	346,510	209,770	1,029,030	163,680	NA	0
1985	2,772,600	2,043,360	222,240	507,000	1,028,000	33,000	413,000	239,000	145,000	198,000	NA	331,880	55,310	269,000	2,138,240	990,000	1,148,240	100%	NA	NA	NA	858,400	331,880	319,820	206,700	689,670	168,730	NA	0
1986	2,529,700	1,619,740	218,960	691,000	891,000	33,000	334,000	239,000	87,000	198,000	NA	252,010	55,240	154,000	2,098,600	990,000	1,108,600	89%	NA	NA	NA	814,810	252,010	366,460	196,340	637,210	177,600	NA	6,000
1987	2,284,200	1,645,660	198,540	440,000	769,000	33,000	239,000	221,000	78,000	198,000	NA	282,430	55,180	91,000	1,893,000	990,000	903,000	64%	NA	NA	NA	758,960	282,430	293,230	183,300	574,220	184,740	NA	124,000
1988	2,357,800	1,944,250	206,550	207,000	701,000	33,000	271,000	152,000	64,000	181,000	NA	277,340	55,330	99,000	1,960,190	990,000	970,190	72%	NA	NA	NA	737,700	277,340	271,450	188,910	563,580	174,120	NA	92,000
1989	2,707,800	2,022,590	223,210	462,000	915,000	33,000	376,000	205,000	103,000	198,000	NA	386,550	55,500	174,000	2,116,720	990,000	1,126,720	96%	NA	NA	NA	880,440	386,550	289,000	204,890	705,610	174,830	NA	0
1990	3,108,800	2,246,510	218,290	644,000	1,063,000	33,000	437,000	239,000	156,000	198,000	NA	576,620	83,890	364,000	2,138,350	990,000	1,148,350	100%	NA	NA	NA	1,118,250	576,620	335,750	205,880	932,790	185,460	NA	0
1991	3,038,100	1,927,730	219,370	891,000	1,048,000	33,000	437,000	239,000	141,000	198,000	NA	475,980	96,320	394,000	2,138,220	990,000	1,148,220	100%	NA	NA	NA	1,016,760	475,980	328,300	212,480	836,920	179,840	NA	0
1992	2,125,600	1,188,050	173,550	764,000	772,000	33,000	223,000	239,000	87,000	190,000	NA	141,620	55,730	98,000	1,894,780	990,000	904,780	68%	NA	NA	NA	551,220	141,620	228,220	181,380	390,780	160,440	NA	143,000
1993	2,093,500	1,649,230	189,270	255,000	661,000	33,000	248,000	161,000	74,000	145,000	NA	206,660	55,590	83,000	1,786,480	990,000	796,480	56%	NA	NA	NA	668,290	206,660	293,860	167,770	514,140	154,150	NA	213,000
1994	1,754,100	1,387,420	160,680	206,000	563,000	33,000	211,000	124,000	63,000	132,000	NA	188,210	56,050	67,000	1,486,910	990,000	496,910	28%	NA	NA	NA	473,890	188,210	148,530	137,150	322,140	151,750	NA	397,000
1995	2,930,500	2,127,110	224,390	579,000	946,000	33,000	435,000	195,000	85,000	198,000	NA	515,190	86,230	242,000	2,137,710	990,000	1,147,710	100%	NA	NA	NA	1,135,970	515,190	411,380	209,400	968,700	167,270	NA	0
1996	3,232,300	2,153,690	207,610	871,000	1,027,000	33,000	428,000	239,000	129,000	198,000	NA	710,260	74,780	367,000	2,138,470	990,000	1,148,470	100%	NA	NA	NA	1,278,740	710,260	354,080	214,400	1,107,470	171,270	NA	0
1997	4,535,200	3,703,090	227,110	605,000	1,064,000	33,000	437,000	239,000	157,000	198,000	NA	1,801,780	178,010	559,000	2,138,400	990,000	1,148,400	100%	NA	NA	NA	2,389,480	1,801,780	368,510	219,190	2,224,140	165,340	NA	0
1998	3,165,200	2,114,970	213,230	837,000	1,018,000	33,000	418,000	239,000	130,000	198,000	NA	730,310	55,470	273,000	2,138,450	990,000	1,148,450	100%	NA	NA	NA	1,362,480	730,310	419,170	213,000	1,185,370	177,110	NA	0
1999	4,013,500	3,180,060	216,440	617,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,189,140	286,700	659,000	2,138,260	990,000	1,148,260	100%	NA	NA	NA	1,734,090	1,189,140	332,890	212,060	1,557,080	177,010	NA	0
2000	3,285,500	2,273,320	222,180	790,000	1,063,000	33,000	437,000	239,000	156,000	198,000	NA	761,450	90,250	355,000	2,138,690	990,000	1,148,690	100%	NA	NA	NA	1,317,360	761,450	338,670	217,240	1,138,680	178,680	NA	0
2001	1,803,200	1,298,760	159,440	345,000	578,000	33,000	151,000	204,000	71,000	119,000	NA	130,860	57,040	76,000	1,597,690	990,000	607,690	40%	NA	NA	NA	399,260	130,860	120,970	147,430	250,160	149,100	NA	332,000
2002	3,264,800	2,574,140	221,660	469,000	1,062,000	33,000	437,000	238,000	156,000	198,000	NA	717,550	95,480	377,000	2,138,480	990,000	1,148,480	100%	NA	NA	NA	1,156,800	717,550	232,630	206,620	999,850	156,950	NA	1,000
2003	2,580,400	1,734,340	210,060	636,000	928,000	33,000	387,000	234,000	76,000	198,000	NA	287,600	55,330	170,000	2,104,940	990,000	1,114,940	92%	NA	NA	NA	800,960	287,600	315,910	197,450	634,080	166,880	NA	11,000
2004	2,512,300	1,752,670	199,630	560,000	843,000	33,000	314,000	239,000	59,000	198,000	NA	222,650	55,970	172,000	2,112,090	990,000	1,122,090	94%	NA	NA	NA	765,560	222,650	343,100	199,810	600,800	164,760	NA	9,000
2005	1,761,900	991,960	139,940	630,000	636,000	33,000	159,000	183,000	85,000	176,000	NA	118,760	56,560	99,000	1,563,850	990,000	573,850	38%	NA	NA	NA	418,590	118,760	152,810	147,020	283,680	134,910	NA	364,000
Min	1,754,100	991,960	139,940	206,000	563,000	33,000	151,000	124,000	59,000	119,000	NA	118,760	55,180	67,000	1,486,910	990,000	496,910	28%	NA	NA	NA	399,260	118,760	120,970	137,150	250,160	134,910	NA	0
Avg	2,816,612	2,007,572	206,600	602,440	908,360	33,000	353,960	220,080	113,120	188,200	NA	506,913	86,369	266,520	2,021,739	990,000	1,031,739	85%	NA	NA	NA	1,015,192	506,913	312,428	195,851	848,646	166,547	NA	67,800
Median	2,772,600	2,022,590	218,290	617,000	946,000	33,000	413,000	239,000	109,000	198,000	NA	386,550	56,560	242,000	2,137,710	990,000	1,147,710	100%	NA	NA	NA	880,440	386,550	328,300	205,880	705,610	166,880	NA	0
Max	4,535,200	3,703,090	227,110	891,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,801,780	286,700	659,000	2,138,690	990,000	1,148,690	100%	NA	A	A	2,389,480	1,801,780	523,060	219,190	2,224,140	185,460	NA	397,000

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Table 3. Yak-RW annual output for the 25-year period of record (1981-2005) for the No Action Alternative (all units are acre-feet unless otherwise noted)

Water year	TWSA (Available volume above Parker) Apr -Sep	Components			Approximate Maximum Storage							Distribution							Columbia River available	Black Rock contents Mar 31 (capacity 1.3)	Black Rock diversion	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return flow volume Apr-Sep	Total Yakima reservoir contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.16)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (average flow)	Total Yakima reservoir contents Sep 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonpro-ratable diversion Apr-Sep (entitle-ments 1.10)	Proratable Diversion Apr-Sep (entitle-ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,501,000	1,429,980	222,020	849,000	944,000	33,000	326,000	239,000	148,000	198,000	NA	251,600	97,880	233,000	1,997,640	940,000	1,057,640	92%	NA	NA	NA	621,210	251,600	245,520	124,090	433,860	187,350	NA	0
1982	3,445,000	2,593,270	222,730	629,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	936,850	182,180	488,000	1,992,360	940,000	1,052,360	100%	NA	NA	NA	1,501,780	936,850	430,870	134,060	1,310,360	191,420	NA	0
1983	3,390,500	2,355,890	222,610	812,000	1,021,000	33,000	437,000	239,000	114,000	198,000	NA	918,410	162,420	452,000	1,992,380	940,000	1,052,380	100%	NA	NA	NA	1,573,090	918,410	523,060	131,620	1,386,530	186,560	NA	5,000
1984	3,286,600	2,231,520	225,080	830,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	771,340	191,920	494,000	1,992,040	940,000	1,052,040	100%	NA	NA	NA	1,251,080	771,340	346,510	133,230	1,058,590	192,490	NA	1,000
1985	2,806,500	2,043,360	222,140	541,000	1,038,000	33,000	416,000	239,000	152,000	198,000	NA	490,440	118,610	296,000	1,992,340	940,000	1,052,340	100%	NA	NA	NA	939,750	490,440	319,820	129,490	742,200	197,550	NA	0
1986	2,553,700	1,619,740	218,960	715,000	930,000	33,000	360,000	239,000	100,000	198,000	NA	350,440	97,460	207,000	1,975,440	940,000	1,035,440	90%	NA	NA	NA	838,660	350,440	366,460	121,760	632,320	206,340	NA	0
1987	2,335,500	1,645,660	201,840	488,000	800,000	33,000	247,000	239,000	83,000	198,000	NA	378,130	92,910	96,000	1,842,420	940,000	902,420	69%	NA	NA	NA	791,750	378,130	293,230	120,390	578,640	213,110	NA	70,000
1988	2,360,100	1,944,250	205,850	210,000	712,000	33,000	277,000	162,000	67,000	173,000	NA	362,720	93,660	110,000	1,867,270	940,000	927,270	72%	NA	NA	NA	755,440	362,720	271,450	121,270	552,870	202,570	NA	62,000
1989	2,714,300	2,022,590	223,710	468,000	938,000	33,000	386,000	212,000	109,000	198,000	NA	483,010	98,900	222,000	1,984,120	940,000	1,044,120	96%	NA	NA	NA	901,390	483,010	289,000	129,380	697,770	203,620	NA	0
1990	3,142,500	2,246,510	217,990	678,000	1,063,000	33,000	437,000	239,000	156,000	198,000	NA	727,520	130,880	399,000	1,992,180	940,000	1,052,180	100%	NA	NA	NA	1,193,310	727,520	335,750	130,040	979,030	214,280	NA	0
1991	3,038,100	1,927,730	219,370	891,000	1,053,000	33,000	437,000	239,000	146,000	198,000	NA	588,280	142,810	434,000	1,991,920	940,000	1,051,920	100%	NA	NA	NA	1,052,530	588,280	328,300	135,950	843,880	208,650	NA	0
1992	2,159,500	1,188,050	175,450	796,000	800,000	33,000	239,000	239,000	92,000	197,000	NA	212,850	93,000	115,000	1,841,520	940,000	901,520	70%	NA	NA	NA	559,920	212,850	228,220	118,850	371,410	188,510	NA	90,000
1993	2,110,400	1,649,230	193,170	268,000	672,000	33,000	248,000	171,000	72,000	148,000	NA	283,560	90,850	82,000	1,723,610	940,000	783,610	57%	NA	NA	NA	686,500	283,560	293,860	109,080	504,180	182,320	NA	171,000
1994	1,749,900	1,387,420	160,480	202,000	562,000	33,000	213,000	123,000	64,000	129,000	NA	252,220	84,940	65,000	1,418,400	940,000	478,400	27%	NA	NA	NA	491,210	252,220	148,530	90,460	314,280	176,930	NA	379,000
1995	2,930,000	2,127,110	224,890	578,000	953,000	33,000	436,000	195,000	91,000	198,000	NA	626,050	133,590	283,000	1,991,690	940,000	1,051,690	100%	NA	NA	NA	1,169,920	626,050	411,380	132,490	973,840	196,080	NA	0
1996	3,232,300	2,153,690	207,610	871,000	1,037,000	33,000	433,000	239,000	134,000	198,000	NA	820,340	122,850	409,000	1,992,190	940,000	1,052,190	100%	NA	NA	NA	1,312,240	820,340	354,080	137,820	1,112,170	200,070	NA	0
1997	4,548,100	3,703,090	228,010	617,000	1,064,000	33,000	437,000	239,000	157,000	198,000	NA	1,936,970	229,800	588,000	1,992,310	940,000	1,052,310	100%	NA	NA	NA	2,448,220	1,936,970	368,510	142,740	2,254,070	194,150	NA	0
1998	3,167,600	2,114,970	213,630	839,000	1,026,000	33,000	422,000	239,000	134,000	198,000	NA	858,580	118,770	299,000	1,992,320	940,000	1,052,320	100%	NA	NA	NA	1,414,610	858,580	419,170	136,860	1,208,680	205,930	NA	0
1999	4,036,100	3,180,060	217,040	639,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,340,190	344,320	682,000	1,992,190	940,000	1,052,190	100%	NA	NA	NA	1,808,670	1,340,190	332,890	135,590	1,602,850	205,820	NA	0
2000	3,286,300	2,273,320	221,980	791,000	1,063,000	33,000	437,000	239,000	156,000	198,000	NA	866,410	124,440	403,000	1,992,410	940,000	1,052,410	100%	NA	NA	NA	1,345,900	866,410	338,670	140,820	1,138,430	207,470	NA	0
2001	1,857,200	1,298,760	163,440	395,000	611,000	33,000	159,000	211,000	81,000	127,000	NA	192,390	89,080	83,000	1,580,710	940,000	640,710	44%	NA	NA	NA	413,770	192,390	120,970	100,410	237,350	176,420	NA	272,000
2002	3,269,800	2,574,140	221,660	474,000	1,064,000	33,000	437,000	239,000	157,000	198,000	NA	840,130	143,910	411,000	1,992,540	940,000	1,052,540	100%	NA	NA	NA	1,203,100	840,130	232,630	130,340	1,017,340	185,760	NA	6,000
2003	2,615,900	1,734,340	209,560	672,000	961,000	33,000	405,000	239,000	86,000	198,000	NA	401,650	97,880	225,000	1,974,750	940,000	1,034,750	92%	NA	NA	NA	840,210	401,650	315,910	122,650	644,560	195,650	NA	5,000
2004	2,563,900	1,752,670	200,230	611,000	913,000	33,000	357,000	239,000	86,000	198,000	NA	317,550	100,130	258,000	1,987,130	940,000	1,047,130	99%	NA	NA	NA	785,320	317,550	343,100	124,670	591,770	193,550	NA	0
2005	1,845,300	991,960	147,340	706,000	684,000	33,000	155,000	230,000	72,000	194,000	NA	180,540	88,060	109,000	1,573,340	940,000	633,340	45%	NA	NA	NA	437,080	180,540	152,810	103,730	274,880	162,200	NA	289,000
Min	1,749,900	991,960	147,340	202,000	562,000	33,000	155,000	123,000	64,000	127,000	NA	180,540	84,940	65,000	1,418,400	940,000	478,400	27%	NA	NA	NA	413,770	180,540	120,970	90,460	237,350	162,200	NA	0
Avg	2,837,844	2,007,572	207,472	622,800	924,160	33,000	360,480	224,240	117,240	189,200	NA	615,527	130,850	297,720	1,906,609	940,000	966,609	86%	NA	NA	NA	1,053,466	615,527	312,428	125,512	858,474	194,992	NA	54,000
Median	2,806,500	2,022,590	217,990	639,000	961,000	33,000	416,000	239,000	114,000	198,000	NA	490,440	118,610	283,000	1,991,920	940,000	1,051,920	100%	NA	NA	NA	939,750	490,440	328,300	129,490	742,200	195,650	NA	0
Max	4,548,100	3,703,090	228,010	891,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,936,970	344,320	682,000	1,997,640	940,000	1,057,640	100%	NA	NA	NA	2,448,220	1,936,970	523,060	142,740	2,254,070	214,280	NA	379,000

Table 4. Yak-RW annual output for the 25-year period of record (1981-2005) for Wymer Dam and Reservoir Alternative, Option 1 (all units are acre-feet unless otherwise noted)

Water year	TWSA (Available volume above Parker) Apr -Sep	Components			Approximate Maximum Storage							Distribution							Columbia River available	Black Rock Contents Mar 31 (capacity 1.3)	Black Rock diversion	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return flow volume Apr-Sep	Total Yakima Reservoir Contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.16)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (average flow)	Total Yakima reservoir contents Sep 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonpro-ratable diversion Apr-Sep (entitle-ments 1.10)	Proratable diversion Apr-Sep (entitle-ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,524,500	1,429,980	222,520	872,000	972,000	33,000	240,000	239,000	148,000	198,000	114,000	249,890	97,930	246,000	2,021,650	940,000	1,081,650	92%	NA	NA	NA	627,950	249,890	245,520	132,540	423,550	204,400	NA	0
1982	3,482,500	2,593,270	223,230	666,000	1,211,000	33,000	437,000	239,000	158,000	198,000	146,000	822,110	173,670	628,000	2,016,350	940,000	1,076,350	100%	NA	NA	NA	1,394,760	822,110	430,870	141,780	1,186,280	208,480	NA	1,000
1983	3,539,400	2,355,890	222,510	961,000	1,192,000	33,000	437,000	239,000	114,000	198,000	171,000	890,490	153,460	618,000	2,016,260	940,000	1,076,260	100%	NA	NA	NA	1,557,630	890,490	523,060	144,080	1,354,040	203,590	NA	6,000
1984	3,430,100	2,231,520	224,580	974,000	1,236,000	33,000	437,000	239,000	158,000	198,000	171,000	741,900	186,960	655,000	2,015,890	940,000	1,075,890	100%	NA	NA	NA	1,233,040	741,900	346,510	144,630	1,023,530	209,510	NA	2,000
1985	2,971,600	2,043,360	222,240	706,000	1,206,000	33,000	413,000	239,000	152,000	198,000	171,000	489,890	119,050	450,000	2,015,980	940,000	1,075,980	100%	NA	NA	NA	947,720	489,890	319,820	138,010	733,130	214,590	NA	0
1986	2,706,400	1,619,740	218,660	868,000	1,084,000	33,000	318,000	239,000	125,000	198,000	171,000	353,860	98,790	336,000	2,008,100	940,000	1,068,100	96%	NA	NA	NA	851,520	353,860	366,460	131,200	628,080	223,440	NA	0
1987	2,467,000	1,645,660	205,340	616,000	918,000	33,000	180,000	239,000	97,000	198,000	171,000	387,710	93,790	178,000	1,890,920	940,000	950,920	73%	NA	NA	NA	811,190	387,710	293,230	130,250	580,940	230,250	NA	57,000
1988	2,445,800	1,944,250	206,550	295,000	803,000	33,000	204,000	159,000	66,000	180,000	161,000	359,650	93,840	184,000	1,892,000	940,000	952,000	73%	NA	NA	NA	761,050	359,650	271,450	129,950	541,420	219,630	NA	64,000
1989	2,787,700	2,022,590	224,110	541,000	1,014,000	33,000	298,000	205,000	109,000	198,000	171,000	482,730	98,640	286,000	2,005,470	940,000	1,065,470	95%	NA	NA	NA	909,420	482,730	289,000	137,690	688,760	220,660	NA	0
1990	3,201,400	2,246,510	218,890	736,000	1,232,000	33,000	436,000	239,000	156,000	198,000	170,000	617,070	128,530	556,000	2,015,780	940,000	1,075,780	100%	NA	NA	NA	1,091,470	617,070	335,750	138,650	860,160	231,310	NA	0
1991	3,171,600	1,927,730	218,870	1,025,000	1,224,000	33,000	437,000	239,000	146,000	198,000	171,000	565,040	154,590	579,000	2,015,590	940,000	1,075,590	100%	NA	NA	NA	1,036,410	565,040	328,300	143,070	810,710	225,700	NA	0
1992	2,314,200	1,188,050	181,150	945,000	938,000	33,000	201,000	239,000	97,000	197,000	171,000	212,750	94,390	204,000	1,916,010	940,000	976,010	76%	NA	NA	NA	571,240	212,750	228,220	130,270	365,520	205,720	NA	62,000
1993	2,210,600	1,649,230	194,370	367,000	747,000	33,000	153,000	177,000	61,000	161,000	162,000	275,520	92,950	87,000	1,843,830	940,000	903,830	68%	NA	NA	NA	691,970	275,520	293,860	122,590	492,410	199,560	NA	112,000
1994	1,763,600	1,387,420	161,180	215,000	576,000	33,000	130,000	123,000	62,000	142,000	86,000	250,970	85,710	60,000	1,444,250	940,000	504,250	29%	NA	NA	NA	499,300	250,970	148,530	99,800	305,020	194,280	NA	383,000
1995	2,956,900	2,127,110	224,790	605,000	1,034,000	33,000	399,000	194,000	91,000	198,000	119,000	559,090	118,920	365,000	2,015,300	940,000	1,075,300	100%	NA	NA	NA	1,110,780	559,090	411,380	140,310	897,650	213,130	NA	0
1996	3,365,300	2,153,690	207,610	1,004,000	1,197,000	33,000	429,000	239,000	134,000	198,000	164,000	791,110	120,020	559,000	2,016,170	940,000	1,076,170	100%	NA	NA	NA	1,289,930	791,110	354,080	144,740	1,072,800	217,130	NA	0
1997	4,687,200	3,703,090	227,110	757,000	1,235,000	33,000	437,000	239,000	157,000	198,000	171,000	1,900,340	222,580	752,000	2,016,370	940,000	1,076,370	100%	NA	NA	NA	2,419,540	1,900,340	368,510	150,690	2,208,340	211,200	NA	0
1998	3,294,700	2,114,970	213,730	966,000	1,196,000	33,000	421,000	239,000	134,000	198,000	171,000	818,680	119,900	455,000	2,015,220	940,000	1,075,220	100%	NA	NA	NA	1,381,040	818,680	419,170	143,190	1,158,090	222,950	NA	0
1999	4,165,600	3,180,060	216,540	769,000	1,236,000	33,000	437,000	239,000	158,000	198,000	171,000	1,286,970	329,670	853,000	2,016,250	940,000	1,076,250	100%	NA	NA	NA	1,766,810	1,286,970	332,890	146,950	1,543,940	222,870	NA	0
2000	3,421,600	2,273,320	222,280	926,000	1,234,000	33,000	437,000	239,000	156,000	198,000	171,000	841,820	132,930	551,000	2,016,080	940,000	1,076,080	100%	NA	NA	NA	1,329,740	841,820	338,670	149,250	1,105,200	224,540	NA	0
2001	2,018,900	1,298,760	170,140	550,000	706,000	33,000	106,000	212,000	86,000	137,000	132,000	194,310	91,000	88,000	1,749,470	940,000	809,470	59%	NA	NA	NA	431,940	194,310	120,970	116,660	238,050	193,890	NA	181,000
2002	3,288,400	2,574,140	221,260	493,000	1,167,000	33,000	437,000	239,000	157,000	198,000	103,000	766,180	153,010	491,000	2,016,380	940,000	1,076,380	100%	NA	NA	NA	1,136,470	766,180	232,630	137,660	933,670	202,800	NA	7,000
2003	2,719,100	1,734,340	209,760	775,000	1,071,000	33,000	365,000	239,000	107,000	198,000	129,000	397,600	99,350	309,000	2,011,670	940,000	1,071,670	99%	NA	NA	NA	844,400	397,600	315,910	130,890	631,670	212,730	NA	0
2004	2,661,600	1,752,670	200,930	708,000	1,021,000	33,000	308,000	239,000	98,000	198,000	145,000	313,990	99,630	338,000	2,015,670	940,000	1,075,670	100%	NA	NA	NA	790,780	313,990	343,100	133,690	580,170	210,610	NA	1,000
2005	1,877,500	991,960	144,540	741,000	704,000	33,000	97,000	223,000	67,000	163,000	121,000	183,660	89,380	95,000	1,627,890	940,000	687,890	49%	NA	NA	NA	450,940	183,660	152,810	114,470	271,570	179,370	NA	274,000
Min	1,763,600	991,960	144,540	215,000	576,000	33,000	97,000	123,000	61,000	137,000	86,000	183,660	85,710	60,000	1,444,250	940,000	504,250	29%	NA	NA	NA	431,940	183,660	120,970	99,800	238,050	179,370	NA	0
Avg	2,938,928	2,007,572	208,116	723,240	1,046,160	33,000	327,760	223,800	119,760	189,680	152,160	590,133	129,948	396,920	1,945,382	940,000	1,005,382	88%	NA	NA	NA	1,037,482	590,133	312,428	134,920	825,388	212,094	NA	46,000
Median	2,956,900	2,022,590	218,660	741,000	1,084,000	33,000	399,000	239,000	125,000	198,000	170,000	489,890	118,920	365,000	2,015,590	940,000	1,075,590	100%	NA	NA	NA	947,720	489,890	328,300	137,690	733,130	212,730	NA	0
Max	4,687,200	3,703,090	227,110	1,025,000	1,236,000	33,000	437,000	239,000	158,000	198,000	171,000	1,900,340	329,670	853,000	2,021,650	940,000	1,081,650	100%	NA	NA	NA	2,419,540	1,900,340	523,060	150,690	2,208,340	231,310	NA	383,000

Table 5. Yak-RW annual output for the 25-year period of record (1981-2005) for Wymer Dam and Reservoir Alternative, Option 2 (all units are acre-feet unless otherwise noted)

Water year	TWSA (available volume above Parker) Apr -Sep	Components			Approximate Maximum Storage							Distribution							Columbia River available	Black Rock contents Mar 31 (capacity 1.3)	Black Rock diversion	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return flow volume Apr-Sep	Total Yakima reservoir contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.16)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (Average Flow)	Total Yakima reservoir contents Sep 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonpro-ratable diversion Apr-Sep (entitle-ments 1.10)	Proratable diversion Apr-Sep (Entitle-ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,627,400	1,429,980	220,420	977,000	994,000	33,000	322,000	239,000	148,000	198,000	54000	332,580	97,990	268,000	2,021,290	940,000	1,081,290	92%	NA	NA	NA	710,750	332,580	245,520	132,650	506,350	204,400	NA	0
1982	3,595,500	2,593,270	221,230	781,000	1,153,000	33,000	437,000	239,000	158,000	198,000	88000	1,002,310	180,920	563,000	2,016,470	940,000	1,076,470	100%	NA	NA	NA	1,575,640	1,002,310	430,870	142,460	1,367,160	208,480	NA	0
1983	3,550,900	2,355,890	223,010	972,000	1,114,000	33,000	437,000	239,000	114,000	198,000	93000	990,670	165,590	529,000	2,016,270	940,000	1,076,270	100%	NA	NA	NA	1,654,080	990,670	523,060	140,350	1,450,490	203,590	NA	5,000
1984	3,447,600	2,231,520	225,080	991,000	1,153,000	33,000	437,000	239,000	158,000	198,000	88000	846,270	191,980	568,000	2,016,100	940,000	1,076,100	100%	NA	NA	NA	1,334,430	846,270	346,510	141,650	1,124,920	209,510	NA	1,000
1985	2,884,700	2,043,360	221,340	620,000	1,125,000	33,000	415,000	239,000	152,000	198,000	88000	484,390	118,610	369,000	2,016,400	940,000	1,076,400	100%	NA	NA	NA	941,960	484,390	319,820	137,750	727,370	214,590	NA	0
1986	2,709,300	1,619,740	218,560	871,000	1,012,000	33,000	355,000	239,000	99,000	198,000	88000	428,140	97,480	276,000	1,995,080	940,000	1,055,080	90%	NA	NA	NA	924,590	428,140	366,460	129,990	701,200	223,390	NA	0
1987	2,451,100	1,645,660	199,440	606,000	873,000	33,000	255,000	238,000	76,000	198,000	73000	424,530	94,550	115,000	1,909,580	940,000	969,580	76%	NA	NA	NA	848,730	424,530	293,230	130,970	618,410	230,320	NA	44,000
1988	2,386,900	1,944,250	205,650	237,000	739,000	33,000	274,000	175,000	66,000	179,000	12000	362,840	94,130	112,000	1,902,710	940,000	962,710	74%	NA	NA	NA	762,920	362,840	271,450	128,630	543,260	219,660	NA	57,000
1989	2,745,800	2,022,590	221,210	502,000	958,000	33,000	383,000	208,000	110,000	198,000	26000	498,780	98,770	229,000	2,007,170	940,000	1,067,170	96%	NA	NA	NA	924,940	498,780	289,000	137,160	704,280	220,660	NA	0
1990	3,250,100	2,246,510	218,590	785,000	1,119,000	33,000	437,000	239,000	156,000	198,000	56000	780,780	131,900	440,000	2,016,210	940,000	1,076,210	100%	NA	NA	NA	1,249,720	780,780	335,750	133,190	1,018,410	231,310	NA	0
1991	3,200,300	1,927,730	218,570	1,054,000	1,141,000	33,000	437,000	239,000	146,000	198,000	88000	661,660	139,350	511,000	2,015,650	940,000	1,075,650	100%	NA	NA	NA	1,134,530	661,660	328,300	144,570	908,830	225,700	NA	0
1992	2,308,800	1,188,050	173,750	947,000	881,000	33,000	237,000	239,000	92,000	197,000	83000	288,380	94,390	147,000	1,898,170	940,000	958,170	76%	NA	NA	NA	645,170	288,380	228,220	128,570	439,510	205,660	NA	72,000
1993	2,177,200	1,649,230	194,970	333,000	713,000	33,000	240,000	191,000	66,000	167,000	16000	290,100	91,500	81,000	1,796,260	940,000	856,260	63%	NA	NA	NA	701,940	290,100	293,860	117,980	502,480	199,460	NA	142,000
1994	1,760,400	1,387,420	159,980	213,000	574,000	33,000	210,000	121,000	63,000	138,000	9000	251,990	84,930	61,000	1,437,760	940,000	497,760	28%	NA	NA	NA	497,410	251,990	148,530	96,890	303,240	194,170	NA	386,000
1995	3,083,000	2,127,110	224,890	731,000	1,032,000	33,000	436,000	194,000	91,000	198,000	80000	704,120	135,860	345,000	2,016,130	940,000	1,076,130	100%	NA	NA	NA	1,253,630	704,120	411,380	138,130	1,040,500	213,130	NA	0
1996	3,394,800	2,153,690	207,110	1,034,000	1,124,000	33,000	432,000	239,000	134,000	198,000	88000	896,400	121,310	483,000	2,016,170	940,000	1,076,170	100%	NA	NA	NA	1,397,100	896,400	354,080	146,620	1,179,970	217,130	NA	0
1997	4,709,200	3,703,090	227,110	779,000	1,219,000	33,000	437,000	239,000	157,000	198,000	155000	2,010,770	295,940	663,000	2,016,690	940,000	1,076,690	100%	NA	NA	NA	2,530,080	2,010,770	368,510	150,800	2,318,880	211,200	NA	0
1998	3,327,600	2,114,970	213,630	999,000	1,121,000	33,000	421,000	239,000	134,000	198,000	96000	913,630	108,100	392,000	2,016,380	940,000	1,076,380	100%	NA	NA	NA	1,474,070	913,630	419,170	141,270	1,251,120	222,950	NA	0
1999	4,203,300	3,180,060	215,240	808,000	1,163,000	33,000	437,000	239,000	158,000	198,000	98000	1,421,010	351,610	759,000	2,016,250	940,000	1,076,250	100%	NA	NA	NA	1,899,130	1,421,010	332,890	145,230	1,676,260	222,870	NA	0
2000	3,448,800	2,273,320	222,480	953,000	1,151,000	33,000	437,000	239,000	156,000	198,000	88000	942,540	124,030	477,000	2,016,500	940,000	1,076,500	100%	NA	NA	NA	1,430,760	942,540	338,670	149,550	1,206,220	224,540	NA	0
2001	1,940,300	1,298,760	163,540	478,000	661,000	33,000	166,000	211,000	68,000	134,000	49000	195,530	89,930	80,000	1,677,720	940,000	737,720	52%	NA	NA	NA	429,370	195,530	120,970	112,870	235,680	193,690	NA	228,000
2002	3,310,500	2,574,140	219,360	517,000	1,089,000	33,000	437,000	235,000	157,000	198,000	29000	853,690	139,120	427,000	2,016,600	940,000	1,076,600	100%	NA	NA	NA	1,221,190	853,690	232,630	134,870	1,018,390	202,800	NA	6,000
2003	2,746,600	1,734,340	210,260	802,000	1,018,000	33,000	403,000	239,000	85,000	198,000	60000	477,260	97,950	268,000	1,998,430	940,000	1,058,430	93%	NA	NA	NA	919,590	477,260	315,910	126,420	706,900	212,690	NA	6,000
2004	2,676,100	1,752,670	200,430	723,000	971,000	33,000	349,000	239,000	80,000	198,000	72000	372,610	99,690	303,000	2,009,470	940,000	1,069,470	98%	NA	NA	NA	843,870	372,610	343,100	128,160	633,270	210,600	NA	1,000
2005	1,917,400	991,960	143,440	782,000	714,000	33,000	159,000	214,000	71,000	193,000	44000	207,460	88,830	98,000	1,644,050	940,000	704,050	50%	NA	NA	NA	475,240	207,460	152,810	114,970	295,850	179,390	NA	262,000
Minimum	1,760,400	991,960	143,440	213,000	574,000	33,000	159,000	121,000	63,000	134,000	9000	195,530	84,930	61,000	1,437,760	940,000	497,760	28%	NA	NA	NA	429,370	195,530	120,970	96,890	235,680	179,390	NA	0
Average	2,954,144	2,007,572	206,772	739,800	992,480	33,000	359,600	224,440	115,800	190,800	68840	665,538	133,378	342,560	1,940,380	940,000	1,000,380	88%	NA	NA	NA	1,111,234	665,538	312,428	133,268	899,158	212,076	NA	48,400
Median	2,884,700	2,022,590	218,560	782,000	1,032,000	33,000	415,000	239,000	114,000	198,000	80000	498,780	108,100	345,000	2,016,100	940,000	1,076,100	100%	NA	NA	NA	941,960	498,780	328,300	134,870	727,370	212,690	NA	0
Maximum	4,709,200	3,703,090	227,110	1,054,000	1,219,000	33,000	437,000	239,000	158,000	198,000	155000	2,010,770	351,610	759,000	2,021,290	940,000	1,081,290	100%	NA	NA	NA	2,530,080	2,010,770	523,060	150,800	2,318,880	231,310	NA	386,000

Table 6. Yak-RW annual output for the 25-year period of record (1981-2005) for the Wymer Dam Plus Yakima River Pump Exchange Alternative (all units are acre-feet unless otherwise noted)

Water Year	TWSA (available volume above Parker) Apr -Sep	Components					Approximate Maximum Storage					Distribution							Columbia River available	Black Rock contents Mar 31 (Capacity 1.3)	Black Rock diversion	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return Flow Volume Apr-Sep	Total Yakima reservoir contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.16)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (average flow)	Total Yakima reservoir contents Sept 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonpro-ratable diversion Apr-Sep (entitle-ments 1.10)	Proratable diversion Apr-Sep (entitle-ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,524,500	1,429,980	222,520	872,000	973,000	33,000	241,000	239,000	148,000	198,000	114000	596,810	274,130	248,000	1,672,470	770,000	902,470	92%	NA	NA	NA	974,360	596,810	245,520	132,030	423,350	551,010	346,610	0
1982	3,484,500	2,593,270	223,230	668,000	1,211,000	33,000	437,000	239,000	158,000	198,000	146000	1,080,890	311,010	629,000	1,758,660	770,000	988,660	100%	NA	NA	NA	1,653,840	1,080,890	430,870	142,080	1,190,440	463,400	254,920	1,000
1983	3,539,900	2,355,890	223,010	961,000	1,191,000	33,000	437,000	239,000	114,000	198,000	170000	1,153,660	291,020	619,000	1,752,510	770,000	982,510	100%	NA	NA	NA	1,820,650	1,153,660	523,060	143,930	1,356,190	464,460	260,870	6,000
1984	3,430,100	2,231,520	224,580	974,000	1,236,000	33,000	437,000	239,000	158,000	198,000	171000	998,570	324,330	656,000	1,758,230	770,000	988,230	100%	NA	NA	NA	1,489,640	998,570	346,510	144,560	1,025,220	464,420	254,920	2,000
1985	2,972,600	2,043,360	222,240	707,000	1,206,000	33,000	413,000	239,000	152,000	198,000	171000	800,690	274,510	451,000	1,704,930	770,000	934,930	100%	NA	NA	NA	1,258,380	800,690	319,820	137,870	735,460	522,920	308,340	0
1986	2,707,900	1,619,740	219,160	869,000	1,087,000	33,000	320,000	239,000	126,000	198,000	171000	698,960	274,190	339,000	1,660,840	770,000	890,840	97%	NA	NA	NA	1,196,070	698,960	366,460	130,650	627,460	568,610	345,170	0
1987	2,470,800	1,645,660	206,140	619,000	921,000	33,000	183,000	239,000	97,000	198,000	171000	742,370	274,150	181,000	1,536,990	770,000	766,990	73%	NA	NA	NA	1,165,340	742,370	293,230	129,740	581,380	583,960	353,700	56,000
1988	2,449,000	1,944,250	206,750	298,000	806,000	33,000	204,000	171,000	66,000	171,000	161000	714,070	274,220	187,000	1,537,680	770,000	767,680	73%	NA	NA	NA	1,114,960	714,070	271,450	129,440	541,280	573,680	354,030	63,000
1989	2,790,600	2,022,590	224,010	544,000	1,023,000	33,000	298,000	211,000	112,000	198,000	171000	820,150	274,190	294,000	1,663,630	770,000	893,630	96%	NA	NA	NA	1,246,440	820,150	289,000	137,290	684,560	561,880	341,220	0
1990	3,208,200	2,246,510	218,690	743,000	1,234,000	33,000	437,000	239,000	156,000	198,000	171000	929,120	285,560	557,000	1,709,840	770,000	939,840	100%	NA	NA	NA	1,403,460	929,120	335,750	138,590	868,850	534,610	303,300	0
1991	3,171,600	1,927,730	218,870	1,025,000	1,224,000	33,000	437,000	239,000	146,000	198,000	171000	840,140	292,070	580,000	1,739,800	770,000	969,800	100%	NA	NA	NA	1,311,890	840,140	328,300	143,450	813,260	498,630	272,950	0
1992	2,315,300	1,188,050	181,250	946,000	940,000	33,000	203,000	239,000	97,000	197,000	171000	564,890	274,150	207,000	1,562,300	770,000	792,300	76%	NA	NA	NA	922,400	564,890	228,220	129,290	364,630	557,770	352,030	61,000
1993	2,213,500	1,649,230	194,270	370,000	750,000	33,000	146,000	189,000	61,000	151,000	170000	632,940	274,250	90,000	1,485,940	770,000	715,940	68%	NA	NA	NA	1,048,670	632,940	293,860	121,870	493,090	555,580	356,010	111,000
1994	1,766,800	1,387,420	161,380	218,000	578,000	33,000	129,000	131,000	62,000	137,000	86000	569,870	241,560	60,000	1,128,110	770,000	358,110	29%	NA	NA	NA	818,690	569,870	148,530	100,290	305,000	513,690	319,330	379,000
1995	2,958,800	2,127,110	224,690	607,000	1,036,000	33,000	400,000	194,000	91,000	198,000	120000	863,050	274,380	368,000	1,709,970	770,000	939,970	100%	NA	NA	NA	1,414,550	863,050	411,380	140,120	898,120	516,430	303,300	0
1996	3,365,600	2,153,690	206,910	1,005,000	1,198,000	33,000	429,000	239,000	134,000	198,000	165000	1,077,850	275,500	560,000	1,728,050	770,000	958,050	100%	NA	NA	NA	1,576,520	1,077,850	354,080	144,590	1,074,140	502,380	285,270	0
1997	4,688,400	3,703,090	227,310	758,000	1,235,000	33,000	437,000	239,000	157,000	198,000	171000	2,140,220	341,930	753,000	1,776,850	770,000	1,006,850	100%	NA	NA	NA	2,659,910	2,140,220	368,510	151,180	2,212,040	447,870	236,670	0
1998	3,295,300	2,114,970	213,330	967,000	1,197,000	33,000	422,000	239,000	134,000	198,000	171000	1,111,650	275,380	456,000	1,721,150	770,000	951,150	100%	NA	NA	NA	1,673,010	1,111,650	419,170	142,190	1,158,850	514,160	291,220	0
1999	4,166,700	3,180,060	216,640	770,000	1,236,000	33,000	437,000	239,000	158,000	198,000	171000	1,527,210	449,190	854,000	1,776,730	770,000	1,006,730	100%	NA	NA	NA	2,007,740	1,527,210	332,890	147,640	1,548,220	459,520	236,670	0
2000	3,421,700	2,273,320	222,380	926,000	1,234,000	33,000	437,000	239,000	156,000	198,000	171000	1,129,100	288,730	552,000	1,727,930	770,000	957,930	100%	NA	NA	NA	1,616,310	1,129,100	338,670	148,540	1,106,510	509,800	285,270	0
2001	2,020,100	1,298,760	170,340	551,000	707,000	33,000	107,000	212,000	86,000	137,000	132000	546,190	273,370	90,000	1,396,600	770,000	626,600	59%	NA	NA	NA	783,120	546,190	120,970	115,960	237,650	545,470	351,590	180,000
2002	3,290,400	2,574,140	221,260	495,000	1,168,000	33,000	437,000	239,000	158,000	198,000	103000	1,037,080	290,710	493,000	1,746,560	770,000	976,560	100%	NA	NA	NA	1,407,850	1,037,080	232,630	138,140	938,040	469,810	267,020	7,000
2003	2,720,300	1,734,340	209,960	776,000	1,072,000	33,000	366,000	239,000	107,000	198,000	129000	738,950	274,220	312,000	1,668,610	770,000	898,610	99%	NA	NA	NA	1,184,850	738,950	315,910	129,990	631,640	553,210	340,470	0
2004	2,664,300	1,752,670	200,630	711,000	1,023,000	33,000	310,000	239,000	98,000	198,000	145000	658,900	274,230	342,000	1,669,240	770,000	899,240	100%	NA	NA	NA	1,135,130	658,900	343,100	133,130	580,250	554,880	344,260	1,000
2005	1,881,900	991,960	144,940	745,000	708,000	33,000	100,000	224,000	67,000	163,000	121000	528,940	268,980	96,000	1,285,530	770,000	515,530	49%	NA	NA	NA	796,090	528,940	152,810	114,340	271,580	524,510	345,130	270,000
Min	1,766,800	991,960	144,940	218,000	578,000	33,000	100,000	131,000	61,000	137,000	86000	528,940	241,560	60,000	1,128,110	770,000	358,110	29%	NA	NA	NA	783,120	528,940	120,970	100,290	237,650	447,870	236,670	0
Avg	2,940,752	2,007,572	208,180	725,000	1,047,760	33,000	328,160	225,360	119,960	188,720	152560	900,091	289,038	398,960	1,635,166	770,000	865,166	88%	NA	NA	NA	1,347,195	900,091	312,428	134,676	826,688	520,506	308,411	45,480
Median	2,958,800	2,022,590	218,690	745,000	1,087,000	33,000	400,000	239,000	126,000	198,000	170000	820,150	274,380	368,000	1,704,930	770,000	934,930	100%	NA	NA	NA	1,258,380	820,150	328,300	137,870	735,460	522,920	308,340	0
Max	4,688,400	3,703,090	227,310	1,025,000	1,236,000	33,000	437,000	239,000	158,000	198,000	171000	2,140,220	449,190	854,000	1,776,850	770,000	1,006,850	100%	NA	NA	NA	2,659,910	2,140,220	523,060	151,180	2,212,040	583,960	356,010	379,000

Table 7. Yak -RW annual output for the 25-year period of record (1981-2005) for the Black Rock Alternative, Option 1 (all units are acre-feet unless otherwise noted)

Water year	TWSA (available volume above Parker) Apr -Sep	Components			Approximate Maximum Storage							Distribution							Columbia River available	Black Rock contents Mar 31 (capacity 1.3)	Black Rock diversion	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return flow volume Apr-Sep	Total Yakima reservoir contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.16)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (average flow)	Total Yakima reservoir contents Sep 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonpro-ratable diversion Apr-Sep (entitle-ments 1.10)	Proratable diversion Apr-Sep (entitle-ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,447,100	1,429,980	222,120	795,000	885,000	33,000	276,000	239,000	142,000	195,000	NA	639,520	188,820	370,000	1,418,950	770,000	648,950	97%	23,562,000	1,300,000	545,490	1,015,370	639,520	245,520	130,330	810,840	204,530	NA	33,000
1982	3,470,600	2,593,270	223,330	654,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,338,660	313,480	654,000	1,461,630	770,000	691,630	100%	33,290,990	1,300,000	550,610	1,912,250	1,338,660	430,870	142,720	1,703,770	208,480	NA	1,000
1983	3,404,300	2,355,890	223,410	825,000	987,000	33,000	411,000	236,000	110,000	197,000	NA	1,314,590	267,630	613,000	1,461,610	770,000	691,610	100%	21,546,000	1,300,000	550,610	1,980,460	1,314,590	523,060	142,810	1,776,870	203,590	NA	5,000
1984	3,282,100	2,231,520	224,580	826,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,143,330	323,680	659,000	1,461,700	770,000	691,700	100%	17,626,500	1,300,000	550,610	1,630,270	1,143,330	346,510	140,430	1,420,760	209,510	NA	1,000
1985	2,919,600	2,043,360	222,240	654,000	1,020,000	33,000	406,000	238,000	149,000	194,000	NA	986,780	241,390	455,000	1,461,580	770,000	691,580	100%	10,221,500	1,300,000	550,610	1,443,050	986,780	319,820	136,450	1,228,460	214,590	NA	0
1986	2,668,900	1,619,740	219,160	830,000	952,000	33,000	361,000	231,000	134,000	193,000	NA	816,490	218,590	378,000	1,461,620	770,000	691,620	100%	13,750,500	1,300,000	550,610	1,314,740	816,490	366,460	131,790	1,091,290	223,450	NA	0
1987	2,424,700	1,645,660	213,040	566,000	854,000	33,000	280,000	239,000	117,000	185,000	NA	741,550	187,380	281,000	1,387,310	770,000	617,310	82%	4,212,000	1,300,000	543,550	1,166,780	741,550	293,230	132,000	936,350	230,430	NA	30,000
1988	2,511,800	1,944,250	218,550	349,000	815,000	33,000	258,000	239,000	88,000	197,000	NA	753,040	199,060	325,000	1,416,730	770,000	646,730	92%	2,467,000	1,055,000	546,660	1,158,710	753,040	271,450	134,220	938,780	219,930	NA	21,000
1989	2,865,400	2,022,590	223,810	619,000	936,000	33,000	333,000	230,000	148,000	192,000	NA	1,026,610	239,780	360,000	1,461,320	770,000	691,320	100%	3,228,500	1,235,000	550,610	1,454,330	1,026,610	289,000	138,720	1,233,650	220,680	NA	0
1990	3,169,300	2,246,510	218,790	704,000	976,000	33,000	371,000	238,000	154,000	180,000	NA	1,200,830	246,280	495,000	1,461,320	770,000	691,320	100%	15,620,000	1,300,000	550,610	1,675,050	1,200,830	335,750	138,470	1,443,740	231,310	NA	0
1991	3,036,200	1,927,730	219,470	889,000	984,000	33,000	404,000	239,000	128,000	180,000	NA	1,006,480	248,710	556,000	1,461,290	770,000	691,290	100%	21,805,000	1,300,000	550,610	1,477,420	1,006,480	328,300	142,640	1,251,720	225,700	NA	0
1992	2,259,700	1,188,050	187,650	884,000	802,000	33,000	292,000	237,000	71,000	169,000	NA	598,910	165,900	281,000	1,392,410	770,000	622,410	80%	3,794,000	1,300,000	541,590	959,310	598,910	228,220	132,180	753,240	206,070	NA	47,000
1993	2,255,300	1,649,230	208,070	398,000	719,000	33,000	206,000	239,000	83,000	158,000	NA	627,990	165,340	253,000	1,360,610	770,000	590,610	73%	2,112,000	1,057,000	531,170	1,048,200	627,990	293,860	126,350	848,550	199,650	NA	81,000
1994	1,942,200	1,387,420	192,780	362,000	534,000	33,000	101,000	235,000	18,000	147,000	NA	577,100	125,690	44,000	1,317,600	770,000	547,600	70%	2,458,000	1,04,5000	521,310	846,490	577,100	148,530	120,860	649,300	197,190	NA	115,000
1995	2,881,100	2,127,110	224,990	529,000	896,000	33,000	377,000	196,000	93,000	197,000	NA	986,940	242,840	415,000	1,461,240	770,000	691,240	100%	10,809,000	1,300,000	550,610	1,537,620	986,940	411,380	139,300	1,324,490	213,130	NA	0
1996	3,229,800	2,153,690	207,110	869,000	980,000	33,000	394,000	237,000	124,000	192,000	NA	1,240,280	246,110	528,000	1,461,520	770,000	691,520	100%	41,997,500	1,300,000	550,610	1,738,680	1,240,280	354,080	144,320	1,521,550	217,130	NA	0
1997	4,579,000	3,703,090	227,910	648,000	1,064,000	33,000	437,000	239,000	157,000	198,000	NA	2,359,650	376,870	739,000	1,461,540	770,000	691,540	100%	50,871,980	1,300,000	550,610	2,877,850	2,359,650	368,510	149,690	2,666,650	211,200	NA	0
1998	3,162,100	2,114,970	213,130	834,000	974,000	33,000	384,000	235,000	130,000	192,000	NA	1,275,850	246,170	418,000	1,461,300	770,000	691,300	100%	19,313,000	1,300,000	550,610	1,836,320	1,275,850	419,170	141,300	1,613,370	222,950	NA	0
1999	4,064,100	3,180,060	217,040	667,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,783,880	514,900	809,000	1,461,420	770,000	691,420	100%	28,045,500	1,300,000	550,610	2,262,950	1,783,880	332,890	146,180	2,040,080	222,870	NA	0
2000	3,255,000	2,273,320	221,680	760,000	1,046,000	33,000	424,000	238,000	154,000	197,000	NA	1,232,450	260,400	548,000	1,461,580	770,000	691,580	100%	19,855,000	1,300,000	550,610	1,718,810	1,232,450	338,670	147,690	1,494,270	224,540	NA	0
2001	1,991,100	1,298,760	187,340	505,000	553,000	33,000	127,000	221,000	65,000	107,000	NA	547,360	136,370	119,000	1,328,360	770,000	558,360	70%	9,912,000	1,300,000	514,250	790,730	547,360	120,970	122,400	596,460	194,270	NA	116,000
2002	3,272,300	2,574,140	221,160	477,000	1,054,000	33,000	426,000	239,000	158,000	198,000	NA	1,256,590	301,830	539,000	1,461,630	770,000	691,630	100%	10,659,000	1,300,000	550,610	1,626,830	1,256,590	232,630	137,610	1,424,030	202,800	NA	6,000
2003	2,703,200	1,734,340	209,860	759,000	976,000	33,000	403,000	239,000	106,000	195,000	NA	848,480	222,900	388,000	1,461,510	770,000	691,510	100%	5,685,500	1,300,000	550,610	1,295,460	848,480	315,910	131,070	1,082,730	212,730	NA	0
2004	2,633,000	1,752,670	200,330	680,000	921,000	33,000	373,000	239,000	100,000	176,000	NA	740,740	214,420	436,000	1,461,480	770,000	691,480	100%	5,408,000	1,300,000	550,610	1,216,870	740,740	343,100	133,030	1,006,260	210,610	NA	0
2005	1,961,800	991,960	170,840	799,000	588,000	33,000	133,000	236,000	54,000	132,000	NA	538,420	133,000	105,000	1,342,030	770,000	572,030	70%	6,359,000	1,300,000	514,110	815,350	538,420	152,810	124,120	635,360	179,990	NA	119,000
Min	1,942,200	991,960	170,840	349,000	534,000	33,000	101,000	196,000	18,000	107,000	NA	538,420	125,690	44,000	1,317,600	770,000	547,600	70%	2,112,000	1,045,000	514,110	790,730	538,420	120,970	120,860	596,460	179,990	NA	0
Avg	2,895,588	2,007,572	212,736	675,280	908,440	33,000	339,520	235,040	118,280	182,600	NA	1,023,301	241,102	430,720	1,432,372	770,000	662,372	93%	15,384,379	1,267,680	544,740	1,471,996	1,023,301	312,428	136,267	1,259,703	212,293	NA	23,000
Median	2,881,100	2,022,590	218,790	680,000	974,000	33,000	377,000	238,000	128,000	193,000	NA	986,940	241,390	418,000	1,461,320	770,000	691,320	100%	10,809,000	1,300,000	550,610	1,454,330	986,940	328,300	137,610	1,233,650	212,730	NA	0
Max	4,579,000	3,703,090	227,910	889,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	2,359,650	514,900	809,000	1,461,700	770,000	691,700	100%	50,871,980	1,300,000	550610	2,877,850	2,359,650	523,060	149,690	2,666,650	231,310	NA	119,000

Table 8. Yak -RW annual output for the 25-year period of record (1981-2005) for the Black Rock Alternative, Option 2 (all units are acre-feet unless otherwise noted)

Water year	TWSA (available volume above Parker) Apr -Sep	Components			Approximate Maximum Storage							Distribution							Columbia River available Nov-Oct	Black Rock contents Mar 31 (capacity 1.3)	Black Rock diversion Apr-Sep	Components				Distribution			Delivery shortage Apr-Sep
		Runoff volume Apr-Sep	Return Flow volume Apr-Sep	Total Yakima reservoir contents Mar 31	Total Yakima reservoir contents Jun 30	Bumping (capacity 0.0337)	Cle Elum (capacity 0.4369)	Kachess (capacity 0.239)	Keechelus (capacity 0.1578)	Rimrock (capacity 0.198)	Wymer (capacity 0.162)	Flow volume past Parker Apr-Sep	Flow volume past Parker Jul-Sep (average flow)	Total Yakima reservoir contents Sep 30	Total diversion volume above Parker (WSAI) Apr-Sep	Nonprorat able diversion Apr-Sep (entitle-ments 1.10)	Proratable diversion Apr-Sep (entitle-ments 1.24)	End of season proration %				Available volume below Parker Apr-Sep	Flow volume past Parker Apr-Sep	Runoff volume Apr-Sep	Return flow volume Apr-Sep	Flow volume at mouth Apr-Sep	Total diversion volume below Parker Apr-Sep	Pump Exchange Apr-Sep	
1981	2,447,100	1,429,980	222,120	795,000	885,000	33,000	276,000	239,000	142,000	195,000	NA	639,520	188,820	370,000	1,418,950	770,000	648,950	97%	23,562,000	1,300,000	545,490	1,015,370	639,520	245,520	130,330	810,840	204,530	NA	33,000
1982	3,470,600	2,593,270	223,330	654,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,216,400	281,770	654,000	1,584,020	770,000	814,020	100%	33,290,990	1,300,000	428,220	1,790,070	1,216,400	430,870	142,800	1,581,590	208,480	NA	1,000
1983	3,404,300	2,355,890	223,410	825,000	987,000	33,000	411,000	236,000	110,000	197,000	NA	1,208,280	247,860	613,000	1,567,970	770,000	797,970	100%	21,546,000	1,300,000	444,250	1,874,220	1,208,280	523,060	142,880	1,670,630	203,590	NA	5,000
1984	3,282,100	2,231,520	224,580	826,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,069,470	293,370	659,000	1,535,720	770,000	765,720	100%	17,626,500	1,300,000	476,620	1,556,500	1,069,470	346,510	140,520	1,346,990	209,510	NA	1,000
1985	2,919,600	2,043,360	222,240	654,000	1,020,000	33,000	406,000	238,000	149,000	194,000	NA	986,780	241,390	455,000	1,461,580	770,000	691,580	100%	10,221,500	1,300,000	550,610	1,443,050	986,780	319,820	136,450	1,228,460	214,590	NA	0
1986	2,668,900	1,619,740	219,160	830,000	952,000	33,000	361,000	231,000	134,000	193,000	NA	816,490	218,590	378,000	1,461,620	770,000	691,620	100%	13,750,500	1,300,000	550,610	1,314,740	816,490	366,460	131,790	1,091,290	223,450	NA	0
1987	2,424,700	1,645,660	213,040	566,000	854,000	33,000	280,000	239,000	117,000	185,000	NA	741,550	187,380	281,000	1,387,310	770,000	617,310	82%	4,212,000	1,300,000	543,550	1,166,780	741,550	293,230	132,000	936,350	230,430	NA	30,000
1988	2,511,800	1,944,250	218,550	349,000	815,000	33,000	258,000	239,000	88,000	197,000	NA	753,040	199,060	325,000	1,416,730	770,000	646,730	92%	2,467,000	1,055,000	546,660	1,158,710	753,040	271,450	134,220	938,780	219,930	NA	21,000
1989	2,865,400	2,022,590	223,810	619,000	936,000	33,000	333,000	230,000	148,000	192,000	NA	1,026,610	239,780	360,000	1,461,320	770,000	691,320	100%	3,228,500	1,235,000	550,610	1,454,330	1,026,610	289,000	138,720	1,233,650	220,680	NA	0
1990	3,169,300	2,246,510	218,790	704,000	976,000	33,000	371,000	238,000	154,000	180,000	NA	1,171,590	246,280	495,000	1,490,580	770,000	720,580	100%	15,620,000	1,300,000	521,350	1,645,840	1,171,590	335,750	138,500	1,414,530	231,310	NA	0
1991	3,036,200	1,927,730	219,470	889,000	984,000	33,000	404,000	239,000	128,000	180,000	NA	1,006,480	248,710	556,000	1,461,290	770,000	691,290	100%	21,805,000	1,300,000	550,610	1,477,420	1,006,480	328,300	142,640	1,251,720	225,700	NA	0
1992	2,259,700	1,188,050	187,650	884,000	802,000	33,000	292,000	237,000	71,000	169,000	NA	598,910	165,900	281,000	1,392,410	770,000	622,410	80%	3,794,000	1,300,000	541,590	959,310	598,910	228,220	132,180	753,240	206,070	NA	47,000
1993	2,255,300	1,649,230	208,070	398,000	719,000	33,000	206,000	239,000	83,000	158,000	NA	627,990	165,340	253,000	1,360,610	770,000	590,610	73%	2,112,000	1,057,000	531,170	1,048,200	627,990	293,860	126,350	848,550	199,650	NA	81,000
1994	1,942,200	1,387,420	192,780	362,000	534,000	33,000	101,000	235,000	18,000	147,000	NA	577,100	125,690	44,000	1,317,600	770,000	547,600	70%	2,458,000	1,045,000	521,310	846,490	577,100	148,530	120,860	649,300	197,190	NA	115,000
1995	2,881,100	2,127,110	224,990	529,000	896,000	33,000	377,000	196,000	93,000	197,000	NA	986,940	242,840	415,000	1,461,240	770,000	691,240	100%	10,809,000	1,300,000	550,610	1,537,620	986,940	411,380	139,300	1,324,490	213,130	NA	0
1996	3,229,800	2,153,690	207,110	869,000	980,000	33,000	394,000	237,000	124,000	192,000	NA	1,198,430	246,110	528,000	1,503,380	770,000	733,380	100%	41,997,500	1,300,000	508,770	1,696,820	1,198,430	354,080	144,310	1,479,690	217,130	NA	0
1997	4,579,000	3,703,090	227,910	648,000	1,064,000	33,000	437,000	239,000	157,000	198,000	NA	2,161,720	319,040	739,000	1,659,570	770,000	889,570	100%	50,871,980	1,300,000	352,610	2,679,900	2,161,720	368,510	149,670	2,468,700	211,200	NA	0
1998	3,162,100	2,114,970	213,130	834,000	974,000	33,000	384,000	235,000	130,000	192,000	NA	1,197,460	246,170	418,000	1,539,740	770,000	769,740	100%	19,313,000	1,300,000	472,180	1,757,990	1,197,460	419,170	141,360	1,535,040	222,950	NA	0
1999	4,064,100	3,180,060	217,040	667,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	1,594,940	430,620	809,000	1,650,420	770,000	880,420	100%	28,045,500	1,300,000	361,640	2,074,070	1,594,940	332,890	146,240	1,851,200	222,870	NA	0
2000	3,255,000	2,273,320	221,680	760,000	1,046,000	33,000	424,000	238,000	154,000	197,000	NA	1,172,630	246,160	548,000	1,521,480	770,000	751,480	100%	19,855,000	1,300,000	490,720	1,659,060	1,172,630	338,670	147,760	1,434,520	224,540	NA	0
2001	1,991,100	1,298,760	187,340	505,000	553,000	33,000	127,000	221,000	65,000	107,000	NA	547,360	136,370	119,000	1,328,360	770,000	558,360	70%	9,912,000	1,300,000	514,250	790,730	547,360	120,970	122,400	596,460	194,270	NA	116,000
2002	3,272,300	2,574,140	221,160	477,000	1,054,000	33,000	426,000	239,000	158,000	198,000	NA	1,153,000	269,160	539,000	1,565,220	770,000	795,220	100%	10,659,000	1,300,000	447,040	1,523,320	1,153,000	232,630	137,690	1,320,520	202,800	NA	6,000
2003	2,703,200	1,734,340	209,860	759,000	976,000	33,000	403,000	239,000	106,000	195,000	NA	848,480	222,900	388,000	1,461,510	770,000	691,510	100%	5,685,500	1,300,000	550,610	1,295,460	848,480	315,910	131,070	1,082,730	212,730	NA	0
2004	2,633,000	1,752,670	200,330	680,000	921,000	33,000	373,000	239,000	100,000	176,000	NA	740,740	214,420	436,000	1,461,480	770,000	691,480	100%	5,408,000	1,300,000	550,610	1,216,870	740,740	343,100	133,030	1,006,260	210,610	NA	0
2005	1,961,800	991,960	170,840	799,000	588,000	33,000	133,000	236,000	54,000	132,000	NA	538,420	133,000	105,000	1,342,030	770,000	572,030	70%	6,359,000	1,300,000	514,110	815,350	538,420	152,810	124,120	635,360	179,990	NA	119,000
Min	1,942,200	991,960	170,840	349,000	534,000	33,000	101,000	196,000	18,000	107,000	NA	538,420	125,690	44,000	1,317,600	770,000	547,600	70%	2,112,000	1,045,000	352,610	790,730	538,420	120,970	120,860	596,460	179,990	NA	0
Avg	2,895,588	2,007,572	212,736	675,280	908,440	33,000	339,520	235,040	118,280	182,600	NA	983,213	230,269	430,720	1,472,486	770,000	702,486	93%	15,384,379	1,267,680	504,632	1,431,929	983,213	312,428	136,288	1,219,636	212,293	NA	23,000
Median	2,881,100	2,022,590	218,790	680,000	974,000	33,000	377,000	238,000	128,000	193,000	NA	986,940	241,390	418,000	1,461,510	770,000	691,510	100%	10,809,000	1,300,000	521,350	1,454,330	986,940	328,300	137,690	1,233,650	212,730	NA	0
Max	4,579,000	3,703,090	227,910	889,000	1,065,000	33,000	437,000	239,000	158,000	198,000	NA	2,161,720	430,620	809,000	1,659,570	770,000	889,570	100%	50,871,980	1,300,000	550,610	2,679,900	2,161,720	523,060	149,670	2,468,700	231,310	NA	119,000

Table 9. Reasons for hydrologic indicators—changes from the No Action Alternative

No.	Hydrologic Indicator (average for period of record 1981-2005 unless otherwise noted)	No Action	Current	Wymer Dam and Reservoir		Wymer Dam Plus	Black Rock	
				Option 1	Option 2		Option 1	Option 2
		(Yak-RW model results are million acre-feet)						
1	**April 1 TWSA**	2.84	2.82	2.94	2.95	2.94	2.90	2.90
a	Decreased due to less September 30 carryover resulting from delivery of the irrigation portion of conserved water during storage control period in non-prorated water years rather than being able to remain in storage as carryover.							
b	Increased by "back-filling" Cle Elum Reservoir storage space vacated by moving water to fill 82,500 acre-feet of Wymer Reservoir.	X						
c	Increased by the 80,000 acre-feet of Wymer Reservoir capacity storing winter water.				X	X		
d	Increased by the 82,500 acre-feet of Wymer Reservoir capacity storing winter water.		X		X			
e	Increased due to more September 30 carryover resulting from storing irrigation portion of conserved water in non-prorated water years.		X					X
f	Increased due to more September 30 carryover by providing exchange participants water supply from another source.							X
g	Increased by return flows resulting from additional proratable water supply being provided in prorated years.					X		X
2	**April-September Flow Volume at Parker**	0.62	0.51	0.59	0.67	0.90	1.02	0.98
a	Decreased without the instream flow portion of conserved water.							
b	Decreased due to diversion of unregulated flow for future municipal water needs.				X	X	X	X
c	Decreased by "back-filling" Cle Elum Reservoir storage space after moving water to Wymer Reservoir.	X						
d	Increased by releases from the 82,500 acre-feet Wymer Reservoir of capacity to improve instream flows.		X					
e	Increased with Yakima River pump exchange and enhanced instream flow goals.		X		X		X	X
3	**April-September Diversion Volume Above Parker**	1.91	2.02	1.95	1.94	1.64	1.43	1.47
a	Increased because No Action Alternative water conservation measures are not included.				X			

No.	Hydrologic Indicator (average for period of record 1981-2005 unless otherwise noted)	No Action	Current	Wymer Dam and Reservoir		Wymer Dam Plus	Black Rock	
				Option 1	Option 2		Option 1	Option 2
		(Yak-RW model results are million acre-feet)						
b	Increased by inclusion of future municipal supply.				X	X	X	X
c	Increased due to more proratable water supply in dry years.				X	X	X	X
d	Decreased due to providing exchange participants water supply from another source.						X	X
4	**September 30 Reservoir Contents**	0.30	0.27	0.40	0.34	0.40	0.43	0.43
a	Decreased due to less September 30 carryover resulting from delivery of the irrigation portion of conserved water during storage control period in non-prorated water years rather than being retained in storage as carryover.				X			
b	Decreased due to inclusion of future municipal water supply.				X	X	X	X
c	Increased by storage in the 80,000 acre-feet of Wymer reservoir capacity carryover for dry year use only.	X			X	X		
d	Increased by not using all of the exchange participants Yakima Project stored water during this period that resulted from the water exchange.		X					X
5	**April-September Flow Volume at the Mouth**	0.86	0.85	0.83	0.90	0.83	1.26	1.22
a	Reduced because water conservation measures of No Action Alternative (instream flow portion) are not included.							
b	Decreased due to inclusion of future municipal water supply.				X	X	X	X
c	Increased by enhanced instream flow goals.				X		X	X
6	**Irrigation Delivery Volume Shortage (1994)**	0.38	0.40	0.38	0.39	0.38	0.12	0.12
a	Increased because No Action Alternative water efficiency measures are not included.		X					
b	No change because delivery efficiency same as no action				X	X		
d	Decreased due to providing exchange participants water supply from another source.	X						X
e	Decreased by using a part of the exchange participants Yakima Project water supply to improve proratable supply of other basin entities.		X					X
7	**Irrigation Proration Level (1994)**	27%	28%	29%	28%	29%	70%	70%
a	Little change without changes to TWSA.		X	X	X	X		
b	Increased with greater TWSA.							X
c	Increased with greater TWSA and providing exchange participants water from another source.							X

Black Rock Alternative Tables

Table 10. Roza Division total water supply with Black Rock Alternative (acre-feet)

Table 11. Roza Division diversions from the Yakima River for lands upstream of Roza Canal MP 22.6 with Black Rock Alternative (acre-feet)

Table 12. Roza Division Black Rock Reservoir deliveries at Roza Canal MP 22.6 (acre-feet)

Table 13. Sunnyside Division total water supply (also the deliveries to Sunnyside Canal at MP 3.83) with the Black Rock Alternative, Option 1 (acre-feet)

Table 14. Sunnyside Division diversions from Yakima River at Sunnyside Diversion Dam with the Black Rock Alternative, Option 2, operation (acre-feet)

Table 15. Sunnyside Division deliveries from Black Rock Reservoir to Sunnyside canal at MP 3.83 with the Black Rock Alternative, Option 2, operation (acre-feet)

Table 16. End-of-month contents for Black Rock Reservoir, Option 1

Table 17. End-of-month contents for Black Rock Reservoir, Option 2 (acre-feet) (results from Yak-RW model)

Table 18. Pumping Volumes to Black Rock Reservoir, Options 1 (acre-feet)

Table 19. Estimate of Columbia River net change in flow volume (acre-feet) for Black Rock Alternative, Option 2 (based on Yak-RW model results)*

Table 10. Roza Division total water supply with Black Rock Alternative (acre-feet)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	31,940	43,980	50,270	57,770	57,030	37,140	1,340	279,470
1982	32,700	44,930	50,510	57,770	57,030	37,910	19,960	300,810
1983	32,700	44,930	50,510	57,770	57,030	37,890	19,920	300,750
1984	32,700	44,930	50,510	57,770	57,030	37,940	20,020	300,900
1985	32,700	44,930	50,510	57,770	57,030	37,870	19,890	300,700
1986	32,700	44,930	50,500	57,770	57,030	37,890	19,870	300,690
1987	32,700	44,400	49,700	57,330	56,740	34,950	1,180	277,000
1988	32,700	44,790	49,930	57,770	57,030	36,610	1,190	280,020
1989	32,700	44,930	50,510	57,770	57,030	37,750	19,950	300,640
1990	32,700	44,930	50,510	57,770	57,030	37,760	19,960	300,660
1991	32,700	44930	50,510	57,770	57,030	37,730	19,900	300,570
1992	32,700	43,530	50,510	56,410	55,780	34,340	1,190	274,460
1993	32,700	44,930	49,980	52,180	51,870	32,170	1,170	265,000
1994	32,700	42,860	49,300	49,430	49,360	30,770	1,100	255,520
1995	32,700	44,930	50,510	57,690	57,030	37,810	20,070	300,740
1996	32,700	44,930	50,510	57,770	57,030	37,840	19,900	300,680
1997	32,700	44,930	50,510	57,770	57,030	37,880	20,070	300,890
1998	32,700	44,930	50,510	57,770	57,030	37,750	19,940	300,630
1999	32,700	44,930	50,510	57,770	57,030	37,820	19,990	300,750
2000	32,700	44,930	50,510	57,770	57,030	37,890	19,960	300,790
2001	26,900	39,160	49,300	49,430	49,430	30,790	1,040	246,050
2002	32,700	44,930	50,510	57,770	57,030	37,930	19,990	300,860
2003	32,700	44,930	50,510	57,770	57,030	37,850	19,940	300,730
2004	32,700	44,930	50,510	57,770	57,030	37,830	19,940	300,710
2005	26,430	39,160	49,300	49,430	49,430	30,890	1,100	245,740
Avg	32,187	44,265	50,278	56,470	55,847	36,440	13,943	289,430
Min	26,430	39,160	49,300	49,430	49,360	30,770	1,040	245,740
Max	32,700	44,930	50,510	57,770	57,030	37,940	20,070	300,900

Table 11. Roza Division diversions from the Yakima River for lands upstream of Roza Canal MP 22.6 with Black Rock Alternative (acre-feet)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	7,100	9,600	10,880	12,440	12,290	8,070	550	60,930
1982	7,260	9,800	10,930	12440	12,290	8,270	4,340	65,330
1983	7,260	9,800	10,930	12440	12,290	8,260	4,300	65,280
1984	7,260	9,800	10,930	12,440	12,290	8,310	4,410	65,440
1985	7,260	9,800	10,930	12,440	12,290	8,240	4,280	65,240
1986	7,260	9,800	10,920	12,440	12,290	8,260	4,250	65,220
1987	7,260	9,690	10,760	12,350	12,230	7,560	400	60,250
1988	7,260	9,770	10,790	12,440	12,290	7,960	410	60,920
1989	7,260	9,800	10,930	12,440	12,290	8,120	4,330	65,170
1990	7,260	9,800	10,930	12,440	12,290	8,120	4,340	65,180
1991	7,260	9,800	10,930	12,440	12,290	8,100	4,290	65,110
1992	7,260	9,510	10,930	12,160	12,030	7,400	410	59,700
1993	7,260	9,800	10,820	11,290	11,230	7,050	390	57,840
1994	7,260	9,370	10,680	10,720	10,650	6,580	320	55,580
1995	7,260	9,800	10,930	12,360	12,290	8,180	4,450	65,270
1996	7,260	9,800	10,930	12,440	12,290	8,210	4,280	65,210
1997	7,260	9,800	10,930	12,440	12,290	8,250	4,450	65,420
1998	7,260	9,800	10,930	12,440	12,290	8,120	4,320	65,160
1999	7,260	9,800	10,930	12,440	12,290	8,190	4,370	65,280
2000	7,260	9,800	10,930	12,440	12,290	8,260	4,340	65,320
2001	6,060	8,610	10,680	10,720	10,720	6,600	250	53,640
2002	7,260	9,800	10,930	12,440	12,290	8,290	4,380	65,390
2003	7,260	9,800	10,930	12,440	12,290	8,220	4,320	65,260
2004	7,260	9,800	10,930	12,440	12,290	8,200	4330	65,250
2005	5,960	8,610	10,680	10,720	10,720	6,700	320	53,710
Avg	7,154	9,662	10,881	12,170	12,044	7,901	3,073	62,884
Min	5,960	8,610	10,680	10,720	10,650	6,580	250	53,640
Max	7,260	9,800	10,930	12,440	12,290	8,310	4,450	65,440

Table 12. Roza Division Black Rock Reservoir deliveries at Roza Canal MP 22.6 (acre-feet)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	24,840	34,380	39,390	45,330	44,730	29,070	780	218,520
1982	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1983	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1984	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1985	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1986	25,440	35,140	39,580	45330	44,730	29,630	15,620	235,470
1987	25,440	34,710	38,940	44,980	44,510	27,390	780	216,750
1988	25,440	35,020	39,140	45,330	44,730	28,660	780	219,100
1989	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1990	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1991	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1992	25,440	34,030	39,580	44,250	43,740	26,940	780	214,760
1993	25,440	35,140	39,160	40,890	40,640	25,130	780	207,180
1994	25,440	33,490	38,620	38,700	38,700	24,190	780	199,920
1995	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1996	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1997	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1998	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
1999	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
2000	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
2001	20,840	30,560	38,620	38,700	38,700	24,190	780	192,390
2002	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
2003	25,440	35,140	39,580	45330	44,730	29,630	15,620	235,470
2004	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470
2005	20,470	30,560	38,620	38,700	38,700	24,190	780	192,020
Avg	25,033	34,611	39,397	44,300	43,794	28,539	10,871	226,545
Min	20,470	30,560	38,620	38,700	38,700	24,190	780	192,020
Max	25,440	35,140	39,580	45,330	44,730	29,630	15,620	235,470

Table 13. Sunnyside Division total water supply (also the deliveries to Sunnyside Canal at MP 3.83) with the Black Rock Alternative, Option 1 (acre-feet)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	36,960	52,060	59,140	63,790	64,080	51,710	24,290	352,030
1982	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1983	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1984	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1985	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1986	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1987	37,330	52,540	58,890	63,790	64,070	50,960	24,290	351,870
1988	37,330	52,620	59,060	63,790	64,080	51,470	24,290	352,640
1989	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1990	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1991	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1992	37,330	52,560	59,240	63,770	63,910	50,810	24,290	351,910
1993	37,330	52,620	58,980	62,790	62,730	50,320	24,290	349,060
1994	37,330	51,820	59,220	61,860	61,860	50,080	24,290	346,460
1995	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1996	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1997	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1998	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1999	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2000	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2001	37,000	52,620	59,220	61,860	61,860	50,080	24,290	346,930
2002	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2003	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2004	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2005	37,230	52,620	59,220	61,860	61,860	50,080	24290	347,160
Avg	37,298	52,560	59,202	63,518	63,752	52,743	28,044	357,117
Min	36,960	51,820	58,890	61,860	61,860	50,080	24,290	346,460
Max	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580

Table 14. Sunnyside Division diversions from Yakima River at Sunnyside Diversion Dam with the Black Rock Alternative, Option 2, operation (acre-feet)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	0	0	0	0	0	0	0
1982	3,110	46,180	41,870	31,230	0	0	1,100	123,490
1983	26,880	33,650	26,050	19,790	0	0	1,380	107,750
1984	12,810	870	30,450	29,860	0	0	1,260	75,250
1985	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0
1990	29,260	0	0	0	0	0	4,850	34,110
1991	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0
1996	36,650	3,510	1,690	0	0	0	2,880	44,730
1997	37,330	52,620	50,630	54,460	2,980	0	24,340	222,360
1998	22,120	34,160	22,160	0	0	0	2,790	81,230
1999	21,370	32,170	51,640	63,710	20,100	0	2,950	191,940
2000	30,230	1,090	14,330	14,260	0	0	3,050	62,960
2001	0	0	0	0	0	0	0	0
2002	19,080	20,800	31,090	32,620	0	0	0	103,590
2003	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0
Avg	9,554	9,002	10,796	9,837	923	-	1,784	41,896
Min	-	-	-	-	-	-	-	-
Max	37,330	52,620	51,640	63,710	20,100	-	24,340	222,360

Table 15. Sunnyside Division deliveries from Black Rock Reservoir to Sunnyside canal at MP 3.83 with the Black Rock Alternative, Option 2, operation (acre-feet)

Water year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	36,960	52,060	59,140	63,790	64,080	51,710	24,290	352,030
1982	34,220	6,440	17,370	32,560	64,080	53,710	28,710	237,090
1983	10,450	18,970	33,190	44,000	64,080	53,710	28430	252,830
1984	24,510	51,750	28,790	33930	64,080	53,710	28,550	285,320
1985	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1986	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1987	37,330	52,540	58,890	63,790	64,070	50,960	24,290	351,870
1988	37,330	52,620	59,060	63,790	64,080	51,470	24,290	352,640
1989	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1990	8,070	52,620	59,240	63,790	64,080	53,710	24,950	326,460
1991	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1992	37,330	52,560	59,240	63,770	63,910	50,810	24,290	351,910
1993	37,330	52,620	58,980	62,790	62,730	50,320	24,290	349,060
1994	37,330	51,820	59,220	61,860	61,860	50,080	24,290	346,460
1995	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1996	680	49,110	57,550	63,790	64,080	53,710	26,930	315,850
1997	0	0	8,610	9,340	61,090	53,710	5,460	138,210
1998	15,210	18,460	37,080	63,790	64,080	53,710	27,020	279,350
1999	15,960	20,450	7,600	90	43,980	53,710	26,860	168,650
2000	7,100	51,530	44,910	49,540	64,080	53,710	26,760	297,630
2001	37,000	52,620	59,220	61,860	61,860	50,080	24,290	346,930
2002	18,250	31,820	28,150	31,180	64,080	53,710	29,810	257,000
2003	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2004	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2005	37,230	52,620	59,220	61,860	61,860	50,080	24,290	347,160
Avg	27,744	43,558	48,406	53,682	62,829	52,743	26,259	315,220
Min	-	-	7,600	90	43,980	50,080	5,460	138,210
Max	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580

Table 16. End-of-month contents for Black Rock Reservoir, Option 1

Water year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980												1,299,801
1981	1,299,794	1,299,774	1,299,719	1,229,080	1,132,284	1,231,019	1,109,912	990,316	1,108,860	1,291,188	1,284,732	1,299,801
1982	1,299,794	1,299,774	1,299,719	1,258,585	1,296,527	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,293,314	1,299,801
1983	1,299,794	1,299,774	1,299,719	1,258,585	1,296,527	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,299,794	1,299,801
1984	1,299,794	1,299,774	1,299,719	1,297,144	1,198,806	1,296,263	1,174,893	1,055,122	1,171,008	1,299,774	1,299,794	1,299,801
1985	1,299,794	1,299,774	1,299,719	1,274,077	1,296,527	1,186,518	1,065,591	946,153	1,062,247	1,224,292	1,299,794	1,293,551
1986	1,299,794	1,299,774	1,299,719	1,297,144	1,198,846	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,293,314	1,287,072
1987	1,299,794	1,299,774	1,299,719	1,228,104	1,130,506	1,022,057	902,151	783,519	904,980	1,087,562	1,081,191	1,074,985
1988	1,068,774	1,062,604	1,055,099	983,926	886,629	778,638	659,362	541,419	661,722	844,644	838,393	832,233
1989	1,041,251	1,035,314	1,234,752	1,297,144	1,296,527	1,186,518	1,065,591	946,153	1,062,247	1,224,292	1,217,863	1,299,801
1990	1,299,794	1,299,774	1,299,719	1,297,144	1,198,846	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,299,794	1,299,801
1991	1,299,794	1,299,774	1,299,719	1,228,104	1,296,527	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,293,314	1,287,072
1992	1,280,824	1,299,774	1,299,719	1,228,070	1,131,100	1,021,624	902,469	784,805	906,900	1,089,529	1,083,175	1,076,975
1993	1,070,763	1,064,814	1,057,353	986,204	888,817	780,900	667,049	554,468	679,370	862,230	855,956	849,789
1994	1,058,803	1,052,859	1,045,411	974,286	879,380	771,805	661,106	551,354	677,447	860,309	854,036	847,869
1995	1,056,884	1,245,275	1,299,719	1,258,585	1,296,527	1,186,518	1,065,591	946,153	1,062,247	1,224,292	1,299,794	1,299,801
1996	1,299,794	1,299,774	1,299,719	1,297,144	1,296,520	1,296,263	1,174,893	1,055,121	1,171,008	1,299,774	1,293,335	1,299,801
1997	1,299,794	1,299,774	1,299,719	1,297,144	1,296,527	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,299,794	1,299,801
1998	1,299,794	1,299,774	1,299,719	1,228,104	1,260,807	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,299,794	1,299,801
1999	1,299,794	1,299,774	1,299,719	1,258,585	1,296,527	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,297,314	1,299,801
2000	1,299,794	1,299,774	1,299,719	1,258,558	1,160,329	1,050,751	930,372	811,458	927,907	1,090,169	1,292,041	1,299,801
2001	1,299,794	1,299,774	1,299,719	1,233,036	1,139,494	1,031,911	919,263	808,576	934,052	1,116,597	1,299,794	1,299,801
2002	1,299,794	1,299,774	1,299,719	1,258,585	1,160,395	1,258,747	1,137,530	1,017,836	1,133,762	1,295,719	1,289,261	1,283,020
2003	1,276,772	1,299,774	1,299,719	1,258,585	1,160,395	1,050,853	930,480	811,520	927,929	1,090,141	1,193,749	1,187,523
2004	1,299,794	1,299,774	1,299,719	1,228,070	1,129,930	1,020,459	900,204	781,394	897,911	1,060,209	1,103,859	1,299,801
2005	1,299,794	1,299,774	1,299,719	1,233,169	1,139,626	1,031,143	919,395	808,707	934,183	1,116,728		

Table 17. End-of-month contents for Black Rock Reservoir, Option 2 (acre-feet) (results from Yak-RW model)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980											1,173,609	1,299,801
1981	1,299,794	1,299,774	1,299,719	1,229,080	1,132,284	1,231,019	1,109,912	990,316	1,108,860	1,291,188	1,284,732	1,299,801
1982	1,299,794	1,299,774	1,299,719	1,261,696	1,298,212	1,298,279	1,208,050	1,088,108	1,203,870	1,299,774	1,293,314	1,299,801
1983	1,299,794	1,299,774	1,299,719	1,276,348	1,298,367	1,296,263	1,194,642	1,074,747	1,190,540	1,299,774	1,299,794	1,299,801
1984	1,299,794	1,299,774	1,299,719	1,297,144	1,199,679	1,298,279	1,206,681	1,086,799	1,202,612	1,299,774	1,299,794	1,299,801
1985	1,299,794	1,299,774	1,299,719	1,274,077	1,296,527	1,186,518	1,065,591	946,153	1,062,247	1,224,292	1,299,794	1,293,551
1986	1,299,794	1,299,774	1,299,719	1,297,144	1,198,846	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,293,314	1,287,072
1987	1,299,794	1,299,774	1,299,719	1,228,104	1,130,506	1,022,057	902,151	783,519	904,980	1,087,562	1,081,191	1,074,985
1988	1,068,774	1,062,604	1,055,099	983,926	886,629	778,638	659,362	541,419	661,722	844,644	838,393	832,233
1989	1,041,251	1,035,314	1,234,752	1,297,144	1,296,527	1,186,518	1,065,591	946,153	1,062,247	1,224,292	1,217,863	1,299,801
1990	1,299,794	1,299,774	1,299,719	1,297,144	1,198,846	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,299,794	1,299,801
1991	1,299,794	1,299,774	1,299,719	1,228,104	1,296,527	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,293,314	1,287,072
1992	1,280,824	1,299,774	1,299,719	1,228,070	1,131,100	1,021,624	902,469	784,805	906,900	1,089,529	1,083,175	1,076,975
1993	1,070,763	1,064,814	1,057,353	986,204	888,817	780,900	667,049	554,468	679,370	862,230	855,956	849,789
1994	1,058,803	1,052,859	1,045,411	974,286	879,380	771,805	661,106	551,354	677,447	860,309	854,036	847,869
1995	1,056,884	1,245,275	1,299,719	1,258,585	1,296,527	1,186,518	1,065,591	946,153	1,062,247	1,224,292	1,299,794	1,299,801
1996	1,299,794	1,299,774	1,299,719	1,297,984	1,296,520	1,296,263	1,174,893	1,055,121	1,171,008	1,299,774	1,293,335	1,299,801
1997	1,299,794	1,299,774	1,299,719	1,298,659	1,298,367	1,297,892	1,230,864	1,113,817	1,229,519	1,299,774	1,299,794	1,299,801
1998	1,299,794	1,299,774	1,299,719	1,250,207	1,296,913	1,296,263	1,174,900	1,055,074	1,170,912	1,299,774	1,299,794	1,299,801
1999	1,299,794	1,299,774	1,299,719	1,278,523	1,298,367	1,298,279	1,240,491	1,140,484	1,256,124	1,299,774	1,297,314	1,299,801
2000	1,299,794	1,299,774	1,299,719	1,273,367	1,176,181	1,080,855	974,564	855,497	971,846	1,137,103	1,299,794	1,299,801
2001	1,299,794	1,299,774	1,299,719	1,233,036	1,139,494	1,031,011	919,263	808,576	934,052	1,116,597	1,299,794	1,299,801
2002	1,299,794	1,299,774	1,299,719	1,268,636	1,191,196	1,296,263	1,207,421	1,087,481	1,203,243	1,299,774	1,293,314	1,287,072
2003	1,280,824	1,299,774	1,299,719	1,258,585	1,160,395	1,050,853	930,480	811,520	927,929	1,090,141	1,193,749	1,187,523
2004	1,299,794	1,299,774	1,299,719	1,228,070	1,129,930	1,020,459	900,204	781,394	897,911	1,060,209	1,103,859	1,299,801
2005	1,299,794	1,299,774	1,299,719	1,233,169	1,139,626	1,031,143	919,395	808,707	934,183	1,116,728		

Table 18. Pumping Volumes to Black Rock Reservoir, Options 1 (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	132,420	6,240	6,020	7,660	0	0	208,260	0	0	208,260	215,210	784,070
1982	0	21,310	6,240	6,020	7,660	30,520	136,360	109,930	0	0	208,260	182,150	708,450
1983	0	12,730	6,240	6,020	7,660	30,520	136,360	109,930	0	0	208,260	182,150	699,870
1984	6,480	6,250	6,240	6,250	7,720	69,140	0	207,540	0	0	208,260	182,000	699,880
1985	6,460	6,240	6,240	6,020	7,660	46,020	120,880	0	0	0	208,260	215,210	622,990
1986	81,950	0	12,490	6,020	7,660	69,100	0	207,460	0	0	208,260	182,150	775,090
1987	0	0	18,970	6,020	7,660	0	0	0	0	0	208,260	215,210	456,120
1988	0	0	0	0	0	0	0	0	0	0	208,260	215,210	423,470
1989	0	0	215,210	0	207,000	134,010	97,820	0	0	0	208,260	215,210	1,077,510
1990	0	88,180	6,240	6,020	7,660	69,100	0	207,460	0	0	208,260	182,150	775,070
1991	6,480	6,250	6,240	6,020	7,660	0	166,810	109,930	0	0	208,260	182,150	699,800
1992	0	0	0	25,220	7,720	0	0	0	0	0	208,260	215,210	456,410
1993	0	0	0	0	0	0	0	0	0	0	208,260	215,210	423,470
1994	0	0	215,210	0	0	0	0	0	0	0	208,260	215,210	638,680
1995	0	0	215,210	194,380	62,160	30,520	136,360	0	0	0	208,260	215,210	1,062,100
1996	81,960	6,250	6,240	6,250	7,720	69,140	97,850	109,980	0	0	208,260	182,000	775,650
1997	0	12,700	6,240	6,020	7,660	69,100	97,820	109,930	0	0	208,260	182,150	699,880
1998	6,480	6,250	6,240	6,020	7,660	0	131,000	145,630	0	0	208,260	182,150	699,690
1999	6,480	6,250	6,240	6,020	7,660	30,520	136,360	109,930	0	0	208,260	182,150	699,870
2000	4,000	8,730	6,240	6,250	7,720	30,530	0	0	0	0	208,260	215,210	486,940
2001	208,260	14,000	6,240	6,020	7,660	0	0	0	0	0	208,260	215,210	665,650
2002	189,620	6,250	6,240	6,020	7,660	30,520	0	208,260	0	0	208,260	215,210	878,040
2003	0	0	0	29,040	7,660	30,520	0	0	0	0	208,260	215,210	490,690
2004	110,000	0	118,520	6,250	7,720	0	0	0	0	0	208,260	215,210	665,960
2005	50,000	202,160	6,240	6,020	7,660	0	0	0	0	0	208,260	215,210	695,550
Avg	30,327	21,439	35,568	14,317	16,906	29,570	50,305	73,770	-	-	208,260	201,974	682,436
Min	-	-	-	-	-	-	-	-	-	-	208,260	182,000	423,470
Max	208,260	202,160	215,210	194,380	207,000	134,010	166,810	208,260	-	-	208,260	215,210	1,077,510

Table 19. Estimate of Columbia River net change in flow volume (acre-feet) for Black Rock Alternative, Option 2 (based on Yak-RW model results)*

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	13,100	-118,810	7,230	6,220	5,760	86,080	132,660	-121,340	45,010	31,620	-178,140	-183,870	-274,480
1982	13,460	-6,550	16,550	15,980	39,240	89,550	-29,790	-54,180	38,520	37,040	-170,720	-115,880	-126,780
1983	13,020	14,060	72,120	8,750	36,120	31,280	-8,870	220	33,190	35,080	-170,880	-130,160	-66,070
1984	15,370	19,490	106,690	10,530	9,340	5,350	198,910	-227,270	38,680	36,290	-170,820	-116,510	-73,950
1985	8,090	12,770	12,420	8,220	5,270	49,470	48,930	115,110	52,910	44,720	-164,380	-176,730	16,800
1986	-68,400	12,450	360	6,260	7,620	18,330	158,340	-98,170	51,400	44,140	-164,460	-155,240	-187,370
1987	19,140	16,220	-4,850	6,520	6,320	72,340	118,290	88,460	47,710	34,250	-176,120	-185,270	43,010
1988	21,850	15,310	4,820	5,490	13,030	71,120	130,270	94,230	49,610	39,260	-171,280	-184,610	89,100
1989	18,890	14,250	-201,430	12,240	-188,700	-20,170	54,290	145,580	57,430	51,340	-157,130	-186,420	-399,830
1990	17,410	-70,230	8,360	6,570	20,130	14,230	209,950	-135,260	46,690	44,390	-164,730	-141,420	-143,910
1991	35,910	27,340	11,550	6,500	5,420	77,280	-17,250	-16,220	38,880	40,840	-164,910	-143,380	-98,040
1992	14,750	13,780	12,580	-22,390	5,780	88,300	150,450	85,650	44,530	25,140	-185,330	-194,020	39,220
1993	12,840	11,540	11,070	10,270	12,930	74,580	121,140	87,230	46,270	26,470	-184,290	-192,650	37,400
1994	9,670	1,200	-209,890	5,260	12,150	67,030	145,320	86,100	44,550	14,770	-196,880	-204,440	-225,160
1995	16,410	15,520	-200,960	-181,860	-48,840	49,470	-35,670	78,290	39,260	44,670	-164,780	-169,690	-558,180
1996	-10,820	31,780	18,170	5,880	-900	-6,070	36,090	-6,130	56,460	44,510	-164,850	-142,700	-138,580
1997	14,070	750	29,650	23,670	11,090	10,210	-7,490	6,150	39,750	32,260	-176,680	-64,370	-80,940
1998	87,690	14,630	5,040	7,350	11,960	35,680	-56,510	36,640	59,890	44,980	-164,650	-143,100	-60,400
1999	8,270	7,270	7,260	6,230	49,450	46,000	-28,770	-8,150	41,190	27,370	-176,690	-62,640	-83,210
2000	102,630	35,500	6,720	5,130	1,610	-7,250	141,700	40,900	52,950	44,860	-164,670	-180,030	80,050
2001	-155,700	5,760	4,890	3,460	4,380	83,420	152,620	84,890	42,770	18,370	-196,350	-203,920	-155,410
2002	-174,610	9,270	7,730	6,330	5,820	50,660	115,990	-168,640	46,620	44,970	-164,650	-111,400	-331,910
2003	12,230	11,930	14,520	-12,610	5,900	41,270	148,100	110,890	52,350	45,540	-162,970	-187,430	79,720
2004	-91,660	16,100	-104,030	6,860	5,970	81,590	139,090	98,010	49,300	40,970	-167,000	-190,900	-115,700
2005	-31,720	-186,120	8,280	6,450	2,780	85,920	155,460	83,660	42,670	16,070	-196,110	-203,270	-215,930
Avg	-3,124	-2,992	-14,206	-1,468	1,585	47,827	86,930	16,266	46,344	36,397	-172,779	-158,802	-118,022
Min	-174,610	-186,120	-209,890	-181,860	-188,700	-20,170	-56,510	-227,270	33,190	14,770	-196,880	-204,440	-558,180
Max	102,630	35,500	106,690	23,670	49,450	89,550	209,950	145,580	59,890	51,340	-157,130	-62,640	89,100

*Net volume change is calculated as the difference in volumes in the Yakima River at Kiona Gage between the Black Rock and No Action Alternatives, less the volume pumped to Black Rock reservoir after accounting for seepage returns. Seepage from Black Rock reservoir returning to the Columbia River was estimated at 97 cfs per day.

Wymer Dam and Reservoir Alternative Tables

Table 20. Monthly releases from the 82,500-acre-foot Wymer reservoir, Option 2

Table 211. End-of-month contents for Wymer reservoir, Option 1 (acre-feet)

Table 2222. End-of-month contents for Wymer reservoir, Option 2 (acre-feet) (results from Yak-RW model)

Table 20. Monthly releases from the 82,500-acre-foot Wymer reservoir, Option 2

Water year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1980												0	0
1981	0	0	0	60,044	22,456	0	0	0	0	0	0	0	82,500
1982	0	0	0	61,561	16,079	4,860	0	0	0	0	0	0	82,500
1983	0	0	0	14,150	26,338	37,299	4,712	0	0	00	0	0	82,500
1984	0	0	0	22,477	60,023	0	0	0	0	0	0	0	82,500
1985	0	0	0	1,300	0	0	0	0	0	0	0	0	1,300
1986	0	0	0	38,736	43,764	0	0	0	0	0	0	0	82,500
1987	0	0	0	38,199	10,957	0	0	0	0	0	0	0	49,156
1988	0	0	0	4,036	0	0	0	0	0	0	0	0	4,036
1989	0	0	0	12,227	5,569	0	0	0	0	0	0	0	17,796
1990	0	0	0	9,258	61,586	0	0	0	0	0	0	0	70,844
1991	0	0	0	21,959	57,474	3,067	0	0	0	0	0	0	82,500
1992	0	0	0	61,695	13,779	0	0	0	0	0	0	0	75,474
1993	0	0	0	12,610	0	0	0	0	0	0	0	0	12,610
1994	0	0	0	2,145	0	0	0	0	0	0	0	0	2,145
1995	0	0	0	30,556	29,861	22,083	0	0	0	0	0	0	82,500
1996	0	0	0	0	53,809	28,691	0	0	0	0	0	0	82,500
1997	0	0	0	0	0	15,504	14,538	27,792	24,665	0	0	0	82,500
1998	0	0	0	12,385	21,465	38,563	7,513	0	0	0	0	0	79,926
1999	0	0	0	35,196	25,985	11,719	4,639	4,961	0	0	0	0	82,500
2000	0	0	0	7,726	51,836	22,939	0	0	0	0	0	0	82,500
2001	0	0	0	807	0	0	0	0	0	0	0	0	807
2002	0	0	0	22,232	2,010	0	0	0	0	0	0	0	24,242
2003	0	0	0	32,373	50,127	0	0	0	0	0	0	0	82,500
2004	0	0	0	30,673	28,501	0	0	0	0	0	0	0	59,174
2005	0	0	0	24,264	0	0	0	0	0	0			24,264

Table 211. End-of-month contents for Wymer reservoir, Option 1 (acre-feet)

Water year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980												46,558
1981	75,663	112,650	136,651	76,607	54,151	54,151	54,151	54,151	54,151	54,151	54,151	54,151
1982	80,664	131,427	170,500	108,939	92,860	88,000	88,000	88,000	88,000	88,000	88,000	88,326
1983	134,477	157,640	170,500	156,350	130,011	92,712	88,000	88,000	88,000	88,000	89,849	89,849
1984	143,647	170,500	170,500	148,023	88,000	88,000	88,000	88,000	88,000	88,000	88,000	88,000
1985	88,000	88,000	89,300	88,000	88,000	88,000	88,000	88,000	88,000	88,077	94,886	94,886
1986	94,886	111,067	170,500	131,764	88,000	88,000	88,000	88,000	88,000	88,000	101,619	101,619
1987	101,619	101,619	137,156	98,957	88,000	73,133	51,186	29,239	8,000	8,000	8,000	8,000
1988	8,000	9,800	16,073	12,036	12,036	12,036	12,036	12,036	12,036	12,036	12,643	15,742
1989	21,154	28,265	43,923	31,696	26,127	26,127	26,127	26,127	26,127	26,127	26,312	32,146
1990	51,618	78,659	127,236	117,979	56,392	56,392	56,392	56,392	56,392	59,663	108,860	138,892
1991	170,500	170,500	170,500	148,541	91,067	88,000	88,000	88,000	88,000	88,000	88,000	99,082
1992	108,046	129,298	163,474	101,779	88,000	83,102	57,796	32,490	8,000	8,000	8,000	8,000
1993	8,000	8,000	32,096	19,486	18,081	15,602	13,041	10,479	8,000	8,000	8,000	8,000
1994	8,000	8,000	12,290	10,145	9,768	9,333	8,884	8,435	8,000	8,000	8,326	17,533
1995	27,633	97,054	162,228	131,672	101,811	79,728	79,728	79,728	79,728	79,728	131,287	162,228
1996	170,500	170,500	170,500	170,500	116,691	88,000	88,000	88,000	88,000	88,000	88,000	88,000
1997	121,977	169,443	170,500	170,500	170,500	154,996	140,458	112,665	88,000	90,750	99,044	99,564
1998	106,273	125,764	167,926	155,541	134,077	95,513	88,000	88,000	88,000	88,000	88,000	101,298
1999	146,633	151,894	170,500	135,304	109,319	97,600	92,961	88,000	88,000	88,000	134,759	170,500
2000	170,500	170,500	170,500	162,774	110,939	88,000	88,000	88,000	88,000	88,000	88,000	88,000
2001	88,000	88,000	88,807	76,380	62,525	49,117	35,263	21,408	8,000	8,000	8,570	8,901
2002	26,131	39,682	53,305	31,073	29,062	29,062	29,062	29,062	29,062	29,062	29,062	29,062
2003	42,092	87,485	142,713	110,340	60,213	60,213	60,213	60,213	60,213	60,213	63,304	63,686
2004	65,571	70,062	130,815	100,142	71,641	71,641	71,641	71,641	71,641	71,641	71,641	73,377
2005	103,195	103,289	103,289	68,372	56,140	44,302	32,070	19,838	8,000	8,000		

8,000

	End-of-month reservoir contents based on meeting the water delivery criteria (kaf)											
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**
Storage	162,500-acre-foot active capacity reservoir											
Max	134.8	170.5	170.5	170.5	170.5	170.5	170.5	155.0	140.5	112.7	88.0	90.7
Min	8.0	8.0	8.0	8.0	12.3	10.1	9.8	9.3	8.9	8.4	8.0	8.0
Avg	63.8	71.0	86.5	103.2	125.7	102.5	78.1	68.8	64.5	60.2	56.2	56.5
Avg % full	39	44	53	63	77	63	48	42	40	37	35	35

Table 2222. End-of-month contents for Wymer reservoir, Option 2 (acre-feet) (results from Yak-RW model)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980											0	38,558
1981	67,663	104,650	128,651	68,607	46,151	46,151	46,151	46,151	46,151	46,151	46,151	46,151
1982	72,664	123,427	162,500	100,939	84,860	80,000	80,000	80,000	80,000	80,000	80,000	80,326
1983	126,477	149,640	162,500	148,350	122,011	84,712	80,000	80,000	80,000	80,000	81,849	81,849
1984	135,647	162,500	162,500	140,023	80,000	80,000	80,000	80,000	80,000	80,000	80,000	80,000
1985	80,000	80,000	81,300	80,000	80,000	80,000	80,000	80,000	80,000	80,077	86,886	86,886
1986	86,886	103,067	162,500	123,764	80,000	80,000	80,000	80,000	80,000	80,000	93,619	93,619
1987	93,619	93,619	129,156	90,957	80,000	65,133	43,186	21,239	0	0	0	0
1988	0	1,800	8,073	4,036	4,036	4,036	4,036	4,036	4,036	4,036	4,643	7,742
1989	13,154	20,265	35,923	23,696	18,127	18,127	18,127	18,127	18,127	18,127	18,312	24,146
1990	43,618	70,659	119,236	109,979	48,392	48,392	48,392	48,392	48,392	51,663	100,860	130,892
1991	162,500	162,500	162,500	140,541	83,067	80,000	80,000	80,000	80,000	80,000	80,000	91,082
1992	100,046	121,298	155,474	93,779	80,000	75,102	49,796	24,490	0	0	0	0
1993	0	0	24,096	11,486	10,081	7,602	5,041	2,479	0	0	0	0
1994	0	0	4,290	2,145	1,768	1,333	884	435	0	0	326	9,533
1995	19,633	89,054	154,228	123,672	93,811	71,728	71,728	71,728	71,728	71,728	123,287	154,228
1996	162,500	162,500	162,500	162,500	108,691	80,000	80,000	80,000	80,000	80,000	80,000	80,000
1997	113,977	161,443	162,500	162,500	162,500	146,996	132,458	104,665	80,000	82,750	91,044	91,564
1998	98,273	117,764	159,926	147,541	126,077	87,513	80,000	80,000	80,000	80,000	80,000	93,298
1999	138,633	143,894	162,500	127,304	101,319	89,600	84,961	80,000	80,000	80,000	126,759	162,500
2000	162,500	162,500	162,500	154,774	102,939	80,000	80,000	80,000	80,000	80,000	80,000	80,000
2001	80,000	80,000	80,807	68,380	54,525	41,117	27,263	13,408	0	0	570	901
2002	18,131	31,682	45,305	23,073	21,062	21,062	21,062	21,062	21,062	21,062	21,062	21,062
2003	34,092	79,485	134,713	102,340	52,213	52,213	52,213	52,213	52,213	52,213	55,304	55,686
2004	57,571	62,062	122,815	92,142	63,641	63,641	63,641	63,641	63,641	63,641	63,641	65,377
2005	95,195	95,289	95,289	60,372	48,140	36,302	24,070	11,838	0	0		

Wymer Dam Plus Yakima River Pump Exchange Alternative Tables

Table 23. Roza Division total water supply with Wymer Dam Plus Yakima River Pump Exchange Alternative

Table 24. Roza Division diversions from the Yakima River with the Wymer Dam Plus Yakima River Pump Exchange Alterative (acre-feet)

Table 25. Roza Division Pump Exchange deliveries with the Wymer Dam Plus Yakima River Pump Exchange Alternative (acre-feet)

Table 26. Sunnyside total water supply with the Wymer Dam Plus Yakima River Pump Exchange Alternative (acre-feet) (not including Benton ID diversion)

Table 27. Sunnyside Division diversions from the Yakima River with the Wymer Dam Plus Yakima River Pump Exchange Alternative

Table 28. Sunnyside Division deliveries with the Wymer Dam Plus Yakima River Pump Exchange Alternative (acre-feet)

Table 23. Roza Division total water supply with Wymer Dam Plus Yakima River Pump Exchange Alternative

Water year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	32,430	44,970	50,580	57,890	57,140	36,820	1,290	281,120
1982	32,750	44,970	50,580	57,890	57,140	37,990	19,900	301,220
1983	32,760	44,970	50,580	57,890	57,140	37,960	19,860	301,160
1984	32,760	44,970	50,580	57,890	57,140	38,000	19,960	301,300
1985	32,760	44,970	50,580	57,890	57,140	37,950	19,830	301,120
1986	32,710	44,970	50,540	57,890	57,140	37,300	1,110	281,660
1987	32,740	43,100	50,580	52,270	51,930	32,290	1,100	264,010
1988	32,760	42,260	50,580	52,130	51,840	32,350	1,170	263,090
1989	32,750	44,730	50,500	57,890	57,140	37,210	1,220	281,440
1990	32,760	44,970	50,580	57,890	57,140	37,870	19,910	301,120
1991	32,760	44,970	50,580	57,890	57,140	37,880	19,850	301,070
1992	29,000	42,460	50,580	53,730	53,650	33,360	1,150	263,930
1993	32,560	40,830	49,690	49,160	48,770	30,650	1,140	252,800
1994	32,320	21,400	22,600	22,590	22,060	13,480	1,070	135,520
1995	32,750	44,970	50,550	57,890	57,140	37,890	20,030	301,220
1996	32,760	44,970	50,580	57,890	57,140	37,940	19,850	301,130
1997	32,760	44,970	50,580	57,890	57,140	37,970	20,050	301,360
1998	32,760	44,970	50,580	57,890	57,140	37,870	19,880	301,090
1999	32,760	44,970	50,580	57,890	57,140	37,910	19,890	301,140
2000	32,760	44,970	50,580	57,890	57,140	37,970	19,900	301,210
2001	23,450	33,870	42,680	42,370	41,990	26,450	1,090	211,900
2002	32,760	44,970	50,580	57,890	57,140	38,000	19,930	301,270
2003	32,760	44,970	50,570	57,890	57,140	37,470	1,220	282,020
2004	32,750	44,960	50,550	57,890	57,140	37,950	19,880	301,120
2005	19,830	27,820	35,020	35,030	34,960	22,260	1,120	176,040
Avg	31,677	42,438	48,479	53,972	53,349	34,832	11,656	276,402
Min	19,830	21,400	22,600	22,590	22,060	13,480	1,070	135,520
Max	32,760	44,970	50,580	57,890	57,140	38,000	20,050	301,360

Table 24. Roza Division diversions from the Yakima River with the Wymer Dam Plus Yakima River Pump Exchange Alterative (acre-feet)

Water year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	12,620	13,750	17,850	24,070	23,320	12,620	1,290	105,520
1982	12,660	13,750	17,850	24,070	23,320	12,920	8,580	113,150
1983	12,670	13,750	17,850	24,070	23,320	12,890	8,540	113,090
1984	12,670	13,750	17,850	24,070	23,320	12,930	8,640	113,230
1985	12,670	13,750	17,850	24,070	23,320	12,880	8,510	113,050
1986	12,620	13,750	17,810	24,070	23,320	12,640	1,110	105,320
1987	12,650	13,190	17,850	18,450	18,110	12,550	1,100	93,900
1988	12,670	13,040	17,850	18,310	18,020	12,610	1,170	93,670
1989	12,660	13,690	17,770	24,070	23,320	12,590	1,220	105,320
1990	12,670	13,750	17,850	24,070	23,320	12,800	8,590	113,050
1991	12,670	13,750	17,850	24,070	23,320	12,810	8,530	113,000
1992	12,620	13,080	17,850	19,910	19,830	12,580	1,150	97,020
1993	12,640	13,070	16,960	15,340	14,950	12,650	1,140	86,750
1994	12,670	12,930	12,660	13,090	13,090	12,360	1,070	77,870
1995	12,660	13,750	17,820	24,070	23,320	12,820	8,710	113,150
1996	12,670	13,750	17,850	24,070	23,320	12,870	8,530	113,060
1997	12,670	13,750	17,850	24,070	23,320	12,900	8,730	113,290
1998	12,670	13,750	17,850	24,070	23,320	12,800	8,560	113,020
1999	12,670	13,750	17,850	24,070	23,320	12,840	8,570	113,070
2000	12,670	13,750	17,850	24,070	23,320	12,900	8,580	113,140
2001	12,650	13,090	12,670	13,090	13,090	12,560	1,090	78,240
2002	12,670	13,750	17,850	24,070	23,320	12,930	8,610	113,200
2003	12,670	13,750	17,840	24,070	23,320	12,600	1,220	105,470
2004	12,660	13,740	17,820	24,070	23,320	12,880	8,560	113,050
2005	12,600	13,090	12,670	13,090	13,090	12,600	1,120	78,260
Avg	12,657	13,557	17,185	21,782	21,198	12,741	5,317	104,436
Min	12,600	12,930	12,660	13,090	13,090	12,360	1,070	77,870
Max	12,670	13,750	17,850	24,070	23,320	12,930	8,730	113,290

Table 25. Roza Division Pump Exchange deliveries with the Wymer Dam Plus Yakima River Pump Exchange Alternative (acre-feet)

Water year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	19,810	31,220	32,730	33,820	33,820	24,200	0	175,600
1982	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1983	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1984	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1985	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1986	20,090	31,220	32,730	33,820	33,820	24,660	0	176,340
1987	20,090	29,910	32,730	33,820	33,820	19,740	0	170,110
1988	20,090	29,220	32,730	33,820	33,820	19,740	0	169,420
1989	20,090	31,040	32,730	33,820	33,820	24,620	0	176,120
1990	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1991	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1992	16,380	29,380	32,730	33,820	33,820	20,780	0	166,910
1993	19,920	27,760	32,730	33,820	33,820	18,000	0	166,050
1994	19,650	8,470	9,940	9,500	8,970	1,120	0	57,650
1995	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1996	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1997	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1998	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
1999	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
2000	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
2001	10,800	20,780	30,010	29,280	28,900	13,890	0	133,660
2002	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
2003	20,090	31,220	32,730	33,820	33,820	24,870	0	176,550
2004	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070
2005	7,230	14,730	22,350	21,940	21,870	9,660	0	97,780
Avg	19,020	28,881	31,294	32,190	32,151	22,090	6,339	171,967
Min	7,230	8,470	9,940	9,500	8,970	1,120	0	57,650
Max	20,090	31,220	32,730	33,820	33,820	25,070	11,320	188,070

Table 26. Sunnyside total water supply with the Wymer Dam Plus Yakima River Pump Exchange Alternative (acre-feet) (not including Benton ID diversion)

Water year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	37,290	52,620	59,240	63,790	64,080	51,490	24,290	352,800
1982	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1983	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1984	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1985	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1986	37,330	52,620	59,240	63,790	64,080	51,720	24,290	353,070
1987	37,330	52,550	59,240	62,790	62,730	50,330	24,290	349,260
1988	37,330	52,620	59,240	62,750	62,690	50,330	24,290	349,250
1989	37,330	52,520	59,240	63,790	64,080	51,700	24,290	352,950
1990	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1991	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1992	37,240	52,620	59,240	63,170	63,330	50,550	24,290	350,440
1993	37,330	52,420	59,220	61,750	61,610	49,970	24,290	346,590
1994	37,190	50,700	51,000	52,480	52,300	46,370	24,290	314,330
1995	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1996	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1997	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1998	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
1999	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2000	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2001	37,300	52,620	57,850	59,380	59,250	49,140	24,290	339,830
2002	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2003	37,330	52,620	59,240	63,790	64,080	51,850	24,290	353,200
2004	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580
2005	37,250	52,470	55,310	56,820	56,800	48,300	24,290	331,240
Avg	37,315	52,522	58,697	62,694	62,886	52,148	27,381	353,643
Min	37,190	50,700	51,000	52,480	52,300	46,370	24,290	314,330
Max	37,330	52,620	59,240	63,790	64,080	53,710	29,810	360,580

Table 27. Sunnyside Division diversions from the Yakima River with the Wymer Dam Plus Yakima River Pump Exchange Alternative

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	3,350	24,630	34,570	38,240	38,510	18,200	490	157,990
1982	18,620	43,750	53170	51,370	51,660	34,040	10,770	263,380
1983	18,620	43,750	47220	51,370	51,660	34,040	10,770	257,430
1984	18,620	43,750	53,170	51,370	51,660	34,040	10,770	263,380
1985	7,650	31,450	41,270	45,220	45,510	28,090	7,080	206,270
1986	3,580	24,990	34,850	38,510	38,800	19,190	490	160,410
1987	3,150	22,060	33,250	35,870	35,780	11,240	490	141,840
1988	2,920	21,370	33,250	35,820	35,730	11,240	490	140,820
1989	7,640	24,630	34,870	38,520	38,790	19,100	490	164,040
1990	12,690	31,450	41,270	45,220	45,510	28,090	7,080	211,310
1991	12,690	37,600	47,220	51,370	51,660	34,040	10,770	245,350
1992	440	21,500	33,370	36,410	36,580	12,720	490	141,510
1993	2,380	19,370	32,930	34,510	34,330	8,820	490	132,830
1994	1,600	6,080	6,370	6,360	6,180	1,740	490	28,820
1995	12,690	31,450	41,270	45,220	45,510	28,090	7,080	211,310
1996	18,620	37,600	47,220	45,220	45,510	28,090	7,080	229,340
1997	18,620	43750	53,170	57,520	57,810	39,990	14,530	285,390
1998	18,620	37,600	41,270	45,220	45,510	28,090	7,080	223,390
1999	18,620	43,750	53,170	57,520	57,810	39,990	14,530	285,390
2000	18,620	37,600	47,220	45,220	45,510	28,090	7,080	229,340
2001	60	11,670	28,120	26,890	26,350	4,510	490	98,090
2002	18,620	37,600	47,220	51,370	51,660	34,040	10,770	251,280
2003	7,650	24,990	34,980	38,660	38,970	19,710	490	165,450
2004	3,580	24,990	35,020	38,760	39,050	21,840	3,440	166,680
2005	60	6,350	17,140	16,230	16,130	3,670	490	60,070
Ave	9,988	29,349	38,903	41,119	41,287	22,828	5,368	188,844
Min	18,480	41,830	44,930	46,210	46,030	32,650	9,010	239,140
Max	90	6,500	14,610	17,670	17,960	9,080	3,440	75,070

Table 28. Sunnyside Division deliveries with the Wymer Dam Plus Yakima River Pump Exchange Alternative (acre-feet)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	33,940	27,990	24,670	25,550	25,570	33,290	23,800	194,810
1982	18,710	8,870	6,070	12,420	12,420	19,670	19,040	97,200
1983	18,710	8,870	12,020	12,420	12,420	19,670	19,040	103,150
1984	18,710	8,870	6,070	12,420	12,420	19,670	19,040	97,200
1985	29,680	21,170	17,970	18,570	18,570	25,620	22,730	154,310
1986	33,750	27,630	24,390	25,280	25,280	32,530	23,800	192,660
1987	34,180	30,490	25,990	26,920	26,950	39,090	23,800	207,420
1988	34,410	31,250	25,990	26,930	26,960	39,090	23,800	208,430
1989	29,690	27,890	24,370	25,270	25,290	32,600	23,800	188,910
1990	24,640	21,170	17,970	18,570	18,570	25,620	22,730	149,270
1991	24,640	15,020	12,020	12,420	12,420	19,670	19,040	115,230
1992	36,800	31,120	25,870	26,760	26,750	37,830	23,800	208,930
1993	34,950	33,050	26,290	27,240	27,280	41,150	23,800	213,760
1994	35,590	44,620	44,630	46,120	46,120	44,630	23,800	285,510
1995	24,640	21,170	17,970	18,570	18,570	25,620	22,730	149,270
1996	18,710	15,020	12,020	18,570	18,570	25,620	22,730	131,240
1997	18,710	8,870	6,070	6,270	6,270	13,720	15,280	75,190
1998	18,710	15,020	17,970	18,570	18,570	25,620	22,730	137,190
1999	18,710	8,870	6,070	6,270	6,270	13,720	15,280	75,190
2000	18,710	15,020	12,020	18,570	18,570	25,620	22,730	131,240
2001	37,240	40,950	29,730	32,490	32,900	44,630	23,800	241,740
2002	18,710	15,020	12,020	12,420	12,420	19,670	19,040	109,300
2003	29,680	27,630	24,260	25,130	25,110	32,140	23,800	187,750
2004	33,750	27,630	24,220	25,030	25,030	31,870	26,370	193,900
2005	37,190	46,120	38,170	40,590	40670	44,630	23,800	271,170
Avg	27,326	23,173	19,794	21,575	21599	29,320	22,012	164,799
Min	18,710	8,870	6,070	6,270	6,270	13,720	15,280	75,190
Max	37,240	46,120	44,630	46,120	46,120	44,630	26,370	285,510

Yakima RiverWare Model Inflow Data Set

Tables of the Yakima RiverWare (Yak-RW) model inflow data sets used in the Feasibility Study follow. Reservoir inflows were developed by having Yak-RW solve with measured reservoir outflow and reservoir storage. Inflows between river gages were developed by having the Yak-RW model solve with measured gage flows, measured diversion data, and the parameters developed to simulate return flows and routing. The American River, Ahtanum Creek, Yakima River at Kiona, Yakima River at Umtanum, and Columbia River below Priest Rapids observed data were obtained from the USGS. All other measured data were obtained from USBR Hydromet.

Table 29. Bumping Reservoir Inflow Volumes (acre-feet)Table 30. Cle Elum Reservoir Inflow Volumes (acre-feet)

Table 30. Cle Elum Reservoir Inflow Volumes (acre-feet)

Table 31. Inflow Volumes between Naches at Cliffdel Gage and Bumping Reservoir excluding American River (acre-feet)

Table 32. Inflow Volumes between Yakima River at Easton Gage and Kachess and Keechelus Reservoirs (acre-feet)

Table 33. Kachess Reservoir Inflow Volumes (acre-feet)

Table 34. Keechelus Reservoir Inflow Volumes (acre-feet)

Table 35. Inflow Volumes between Yakima River at Kiona gage and Yakima River at Prosser gage (acre-feet)

Table 36. Inflow Volumes between Naches River at Naches gage and Naches River at Cliffdell and Tieton River at Tieton Dam gage (acre-feet)

Table 37. Inflow Volumes between Yakima River at Parker gage and Naches River at Naches and Yakima River at Umtanum gage excluding Ahtanum Creek (acre-feet)

Table 38. Rimrock Reservoir Inflow Volumes (acre-feet)

Table 39. Inflow Volumes between Yakima River at Umtanum gage and Yakima River at Cle Elum gage (acre-feet)

Table 40. Inflow Volumes between Yakima River at Prosser gage and Yakima River at Parker gage (acre-feet)

Table 41. Inflow Volumes between Yakima River at Cle Elum gage and Yakima River at Easton and Cle Elum River at Cle Elum Dam gage (acre-feet)

Table 42. American River Inflow Volumes (acre-feet)

Table 43. Ahtanum Creek Inflow Volumes (acre-feet)

Table 44. Columbia River below Priest Rapids Dam Flow Volumes (acre-feet)

Table 29. Bumping Reservoir Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	18,610	49,040	21,230	22,030	11,460	14,200	27,460	21,230	7,400	4,210	4,230	6,460	207,560
1982	8,300	11,930	8,040	34,260	17,410	12,200	45,640	68,000	22,780	6,670	5,900	8,600	249,730
1983	9,360	18,110	19,380	10,630	18,560	15,470	51,280	42,460	21,090	5,810	5,310	4,420	221,880
1984	17,470	11,620	25,360	11,640	14,390	13,550	35,010	54,540	23,830	6,160	3,680	5,650	222,900
1985	8,090	5,580	3,510	3,190	3,940	19,950	45,760	48,550	9,270	3,780	4,300	9,300	165,220
1986	13,440	4,280	10,610	17,650	27,050	21,380	36,560	28,520	6,210	3,280	4,120	3,930	177,030
1987	19,450	9,290	6,620	7,820	19,120	29,070	51,050	18,570	5,310	2,500	2,300	1,920	173,020
1988	2,180	8,070	5,920	6,060	11,380	28,780	39,560	28,970	9,150	3,020	3,000	4,460	150,550
1989	14,740	11,170	8,990	5,670	8,900	29,410	40,160	38,790	10,210	4,200	3,550	3,260	179,050
1990	9,690	17,670	22,460	9,050	9,010	37,250	32,820	38,150	15,450	6,260	4,730	10,790	213,330
1991	41,720	15,480	14,540	28,920	12,380	19,310	31,990	34,580	21,010	6,600	3,520	2,240	232,290
1992	9,890	10,230	10,890	12,870	17,910	26,160	28,690	10,290	4,530	2,290	2,440	2,330	138,520
1993	5,090	3,170	4,500	4,030	11,560	15,690	50,090	20,430	6,970	3,300	2,340	1,820	128,990
1994	1,390	3,620	6,600	3,920	11,950	25,240	35,710	18,060	5,770	2,570	2,310	5,650	122,790
1995	7,150	18,220	11,870	38,450	19,200	14,620	46,820	34,100	11,870	4,610	3,850	10,180	220,940
1996	58,510	32,650	27,460	52,630	17,230	29,880	30,220	31,250	12,230	6,300	4,830	5,540	308,730
1997	11,400	11,310	22,930	16,160	25,440	26,910	71,670	70,930	35,390	8,300	9,490	23,360	333,290
1998	18,800	12,780	10,840	7,100	11,630	17,700	54,290	34,740	10,360	4,850	3,180	3,440	189,710
1999	13,310	20,940	16,570	7,230	7,900	12,430	36,320	69,240	55,820	19,590	5,560	5,280	270,190
2000	31,820	20,360	8,580	7,310	7,000	27,770	40,140	41,610	13,930	5,880	4,850	5,620	214,870
2001	4,600	3,680	3,650	2,960	6,520	12,140	35,040	17,870	6,730	4,480	2,220	3,140	103,030
2002	15,150	10,170	22,880	9,540	10,410	24,690	40,190	66,720	21,540	5,820	3,440	2,860	233,410
2003	4,130	5,420	24,350	19,460	17,670	20,170	33,230	31,500	7,280	3,900	2,870	7,160	177,140
2004	11,830	9,440	8,710	8,370	11,920	26,040	38,220	24,540	7,810	5,140	6,150	5,700	163,870
2005	9,370	16,660	25,610	8,270	7,640	17,070	22,790	8,720	4,560	2,760	2,830	3,880	130,160
Avg	14,620	13,636	14,084	14,209	13,503	21,483	40,028	36,094	14,260	5,291	4,040	5,880	197,128
Min	1,390	3,170	3,510	2,960	3,940	12,140	22,790	8,720	4,530	2,290	2,220	1,820	103,030
Max	58,510	49,040	27,460	52,630	27,050	37,250	71,670	70,930	55,820	19,590	9,490	23,360	333,290

Table 30. Cle Elum Reservoir Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	51,180	136,700	44,820	55,880	36,440	65,290	98,010	77,510	38,410	17,800	13,850	24,630	660,520
1982	25,520	20,770	31,140	76,210	46,900	46,360	148,620	198,280	80,000	30,270	16,580	24,690	745,340
1983	20,130	42,920	64,600	31,760	61,650	64,190	157,850	105,470	59,830	29,440	19,510	9,100	666,450
1984	54,040	19,980	97,690	31,940	47,770	45,930	100,230	166,580	93,380	24,100	15,640	18,870	716,150
1985	26,160	18,470	10,030	10,210	20,340	94,160	149,550	118,010	42,460	17,320	12,910	38,570	558,190
1986	56,040	10,030	20,730	52,110	79,030	65,030	111,960	92,520	40,810	16,850	10,190	12,060	567,360
1987	57,700	22,350	13,250	13,400	54,900	95,500	147,920	65,370	25,880	8,770	5,510	4,600	515,150
1988	6,800	18,290	9,800	21,840	44,330	115,320	134,460	95,350	48,750	19,610	9,630	38,190	562,370
1989	56,050	44,140	40,230	21,720	23,190	106,990	130,320	117,270	48,350	19,430	4,320	8,770	620,780
1990	60,250	64,540	41,550	33,170	39,650	138,470	120,630	146,430	67,410	19,210	11,000	53,120	795,430
1991	199,530	45,760	47,770	76,360	32,820	80,390	124,370	110,830	87,570	31,250	10,950	6,310	853,910
1992	33,790	48,390	38,440	42,680	69,260	85,610	103,840	48,480	21,110	9,760	15,260	11,500	528,120
1993	26,160	18,250	22,900	17,530	39,460	65,250	170,730	71,570	26,810	12,510	4,800	5,970	481,940
1994	8,400	12,960	23,040	14,750	48,430	104,240	122,830	60,450	32,680	9,980	8,260	17,980	464,000
1995	27,580	43,620	25,540	99,130	54,290	62,000	176,480	103,630	48,710	20,320	8,140	52,030	721,470
1996	206,850	76,490	72,270	108,530	53,290	102,940	100,920	109,340	63,320	23,600	11,190	20,810	949,550
1997	46,710	31,390	42,200	46,350	81,500	97,870	225,940	201,050	111,690	34,900	26,070	69,700	1,015,370
1998	54,130	22,780	26,370	21,180	44,350	69,150	162,850	93,030	36,810	14,160	3,540	8,690	557,040
1999	39,410	51,040	67,390	24,860	25,590	57,630	138,580	224,080	145,880	61,660	12,690	18,010	866,820
2000	90,750	78,140	21,310	13,780	20,830	100,340	132,540	128,200	48,250	12,910	13,510	23,700	684,260
2001	11,420	7,870	10,140	7,390	27,660	53,650	119,490	57,940	29,360	11,610	6,480	19,900	362,910
2002	65,430	32,330	54,920	26,870	30,690	87,540	144,230	199,540	82,250	23,710	7,910	4,960	760,380
2003	14,340	14,180	43,470	46,970	61,500	68,480	108,280	105,320	37,920	20,330	10,050	45,270	576,110
2004	64,920	32,640	23,630	24,740	55,080	94,760	116,230	76,750	34,410	29,340	34,620	24,000	611,120
2005	51,320	64,850	86,370	28,670	29,690	57,100	69,600	33,630	23,940	13,800	6,220	21,130	486,320
Avg	54,184	39,155	39,184	37,921	45,146	80,968	132,658	112,265	55,040	21,306	11,953	23,302	653,082
Min	6,800	7,870	9,800	7,390	20,340	45,930	69,600	33,630	21,110	8,770	3,540	4,600	362,910
Max	206,850	136,700	97,690	108,530	81,500	138,470	225,940	224,080	145,880	61,660	34,620	69,700	1,015,370

Table 31. Inflow Volumes between Naches at Cliffdel Gage and Bumping Reservoir excluding American River (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	8,430	28,780	25,910	24,120	21,080	25,030	34,730	22,470	11,120	4,530	4,770	5,390	216,360
1982	7,450	9,290	7,390	26,980	17,660	23,340	65,640	65,700	15,830	9,750	6,620	4,620	260,270
1983	6,350	11,930	23,470	17,970	45,830	45,940	79,460	37,070	14,580	9,070	7,930	6,940	306,540
1984	17,550	8,290	61,180	27,340	38,850	36,750	56,050	69,900	25,360	5,920	4,130	4,900	356,220
1985	6,150	6,580	6,680	6,960	13,620	69,560	85,650	56,410	13,280	5,170	4,530	5,430	280,020
1986	9,630	5,350	7,700	14,050	57,280	44,280	43,460	30,740	9,310	4,870	4,860	4,080	235,610
1987	8,180	4,230	7,310	9,700	33,060	53,200	68,200	13,490	7,100	4,550	1,050	1,570	211,640
1988	2,620	7,380	11,410	9,360	17,280	61,820	62,760	36,310	14,860	7,270	4,930	4,770	240,770
1989	10,690	12,640	10,090	13,700	17,060	70,410	60,660	31,800	9,560	5,250	1,040	2,950	245,850
1990	13,820	20,130	32,130	16,530	27,350	86,300	57,680	39,470	11,160	5,280	3,170	11,960	324,980
1991	40,880	26,830	20,460	50,870	31,210	47,210	54,150	39,510	19,010	6,660	4,220	4,170	345,180
1992	9,400	15,340	11,840	24,580	45,660	37,350	28,690	9,390	7,520	4,450	2,360	2,890	199,470
1993	5,650	5,830	6,770	6,330	15,980	36,330	54,840	22,890	10,010	5,240	2,970	4,800	177,640
1994	5,460	6,350	7,130	6,770	20,770	55,990	41,130	15,170	9,200	4,680	2,470	4,110	179,230
1995	7,450	17,090	18,020	52,060	45,410	38,040	77,460	39,810	15,310	6,100	3,360	8,730	328,840
1996	49,660	90,420	60,490	78,700	45,520	71,450	54,630	35,670	12,410	5,580	4,340	6,340	515,210
1997	7,840	6,710	15,790	16,790	45,390	77,130	132,430	57,490	19,970	9,330	4,390	10,370	403,630
1998	11,290	11,940	12,750	15,240	32,760	48,310	82,380	39,970	11,160	6,190	3,290	2,870	278,150
1999	6,870	13,760	23,260	9,280	19,140	44,230	78,390	77,990	29,110	16,590	8,490	4,020	331,130
2000	25,630	41,120	14,500	9,600	18,660	73,470	62,310	44,990	16,480	4,880	2,940	3,100	317,680
2001	3,400	4,060	4,690	3,700	9,980	23,540	41,730	12,760	4,170	1,880	1,920	4,240	116,070
2002	7,730	7,700	19,760	11,930	16,850	61,920	76,620	54,990	21,670	6,680	2,620	3,330	291,800
2003	4,700	4,310	9,170	13,510	29,420	53,040	56,390	39,230	13,650	7,350	4,950	5,300	241,020
2004	6,400	6,960	11,150	8,090	32,520	52,810	47,360	24,570	5,710	4,850	4,360	4,700	209,480
2005	5,590	8,660	16,600	9,880	8,920	16,980	27,000	10,660	5,680	4,030	2,660	4,250	120,910
Avg	11,553	15,267	17,826	19,362	28,290	50,177	61,192	37,138	13,329	6,246	3,935	5,033	269,348
Min	2,620	4,060	4,690	3,700	8,920	16,980	27,000	9,390	4,170	1,880	1,040	1,570	116,070
Max	49,660	90,420	61,180	78,700	57,280	86,300	132,430	77,990	29,110	16,590	8,490	11,960	515,210

Table 32. Inflow Volumes between Yakima River at Easton Gage and Kachess and Keechelus Reservoirs (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	15,480	47,050	16,840	21,730	14,630	20,790	22,020	13,920	5,660	1,050	850	6,260	186,280
1982	5,040	8,740	17,150	34,730	26,270	20,650	46,320	23,160	5,010	1,880	2,510	8,750	200,210
1983	7,100	11,440	23,730	10,990	22,840	13,460	22,320	6,590	10,420	5,710	4,030	6,450	145,080
1984	18,820	14,370	45,200	20,740	21,450	16,170	34,610	22,560	8,270	2,240	2,280	3,700	210,410
1985	9,300	4,960	3,470	3,040	10,260	33,300	39,140	8,680	6,250	6,110	4,200	10,240	138,950
1986	22,030	5,330	6,770	14,510	33,860	19,240	24,950	5,540	5,910	670	6,820	3,420	149,050
1987	23,680	11,040	4,880	6,370	22,410	33,700	31,760	7,940	3,770	3,770	1,260	2,130	152,710
1988	2,230	3,930	2,990	12,470	20,390	42,440	33,380	12,460	2,550	6,250	5,540	6,460	151,090
1989	16,540	19,810	20,070	11,280	7,530	51,150	27,420	11,170	4,340	2,500	2,330	5,370	179,510
1990	21,590	21,910	23,060	21,660	18,030	38,250	25,680	18,470	8,240	3,830	2,340	17,700	220,760
1991	77,600	35,630	16,710	40,400	19,020	28,400	21,680	13,040	9,030	5,070	3,630	2,330	272,540
1992	7,480	19,650	12,380	19,520	20,240	15,140	13,680	1,880	3,830	3,580	1,110	2,950	121,440
1993	7,850	7,900	8,070	6,860	16,580	23,170	25,980	6,950	2,970	420	6,070	3,810	116,630
1994	1,910	4,600	11,860	5,920	17,130	33,800	14,230	3,790	780	1,160	1,300	4,740	101,220
1995	9,810	16,260	13,780	35,910	25,430	16,550	26,790	7,560	6,680	2,430	50	8,580	169,830
1996	65,220	41,280	29,400	63,230	28,230	38,230	24,270	5,940	4,600	2,410	3,410	8,170	314,390
1997	11,600	9,980	18,670	22,860	24,690	25,930	74,700	28,180	5,370	2,360	210	10,760	235,310
1998	15,710	10,360	11,270	11,470	17,300	23,010	38,550	10,900	2,820	1,770	1,150	2,260	146,570
1999	9,040	19,460	40,840	17,140	11,020	32,430	57,020	48,360	3,800	0	0	2,700	241,810
2000	14,690	41,140	7,440	3,930	11,810	39,510	36,740	18,480	4,410	1,340	1,470	6,060	187,020
2001	4,430	2,910	3,290	3,630	12,940	21,560	30,770	8,040	9,030	8,130	210	5,900	110,840
2002	12,500	14,450	18,360	10,010	12,880	35,960	44,770	32,050	4,700	6,780	630	2,880	195,970
2003	1,850	2,120	12,040	19,460	20,860	21,740	19,860	7,750	570	180	1,340	2,860	110,630
2004	15,250	10,560	7,190	9,240	20,820	29,220	19,520	9,260	5,160	2,420	1,680	6,160	136,480
2005	8,960	13,490	20,720	8,900	6,410	11,420	10,270	5,910	1,690	10,170	800	4,300	103,040
Avg	16,228	15,935	15,847	17,440	18,521	27,409	30,657	13,543	5,034	3,289	2,209	5,798	171,911
Min	1,850	2,120	2,990	3,040	6,410	11,420	10,270	1,880	570	0	0	2,130	101,220
Max	77,600	47,050	45,200	63,230	33,860	51,150	74,700	48,360	10,420	10,170	6,820	17,700	314,390

Table 33. Kachess Reservoir Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	21,670	52,110	15,230	24,960	13,610	24,820	22,640	19,430	6,940	2,800	3,740	9,300	217,250
1982	8,500	11,220	18,810	35,090	20,870	18,510	48,610	46,930	16,480	4,180	4,240	8,380	241,820
1983	8,150	16,870	29,190	13,920	24,910	22,320	37,610	22,450	11,400	4,090	5,070	3,070	199,050
1984	22,740	9,030	40,950	13,100	20,130	17,380	35,060	41,470	17,380	5,550	3,650	6,700	233,140
1985	11,530	9,490	5,140	4,950	10,170	37,400	46,280	30,030	7,710	1,460	3,820	16,750	184,730
1986	25,400	5,220	8,270	21,810	30,790	22,650	32,200	17,780	7,650	4,210	2,810	4,090	182,880
1987	27,320	8,260	6,830	7,130	21,570	36,240	39,070	14,990	2,420	3,310	1,590	750	169,480
1988	2,710	9,020	5,660	13,260	21,890	40,280	39,000	21,670	6,250	1,530	3,300	11,600	176,170
1989	23,120	18,960	20,650	9,710	10,840	40,500	37,190	25,870	7,040	3,700	1,780	2,800	202,160
1990	23,320	23,640	24,660	19,520	17,810	48,540	36,150	35,520	10,770	2,780	3,760	22,100	268,570
1991	71,770	19,420	20,960	32,120	14,320	29,600	33,240	23,110	12,150	2,930	2,280	2,590	264,490
1992	16,580	24,750	19,270	17,080	21,940	25,140	19,950	6,640	5,110	3,700	4,800	3,390	168,350
1993	12,990	9,010	11,100	6,360	18,150	27,580	47,600	15,240	9,360	3,130	1,510	1,390	163,420
1994	3,970	6,680	14,950	7,920	19,900	34,100	29,940	13,520	4,500	1,420	1,390	8,810	147,100
1995	13,880	21,650	12,590	36,370	21,260	23,060	43,840	18,300	5,780	5,370	6,990	21,790	230,880
1996	75,840	27,110	34,620	42,600	19,480	37,220	33,440	22,690	12,550	5,020	3,650	10,570	324,790
1997	20,630	14,430	20,240	20,140	32,190	37,940	75,310	51,430	24,780	5,690	9,560	23,890	336,230
1998	17,340	11,170	13,290	10,350	17,820	23,780	43,270	19,070	4,520	1,080	2,690	5,480	169,860
1999	20,720	25,860	29,640	13,300	11,970	23,810	46,350	57,670	31,160	9,150	6,440	6,570	282,640
2000	28,090	35,450	10,430	6,140	9,690	35,350	40,470	33,030	7,870	1,500	8,660	9,350	226,030
2001	5,200	4,300	5,070	4,010	13,040	22,960	36,340	15,900	2,860	7,340	5,520	10,250	132,790
2002	23,950	14,910	23,080	11,810	14,070	35,320	47,880	50,970	15,190	910	2,920	2,250	243,260
2003	5,330	5,650	21,830	18,230	28,250	24,320	29,170	18,620	6,860	4,350	4,970	14,720	182,300
2004	25,720	12,020	12,480	9,990	21,850	31,840	32,290	15,810	2,040	6,420	13,120	10,830	194,410
2005	18,230	23,860	28,180	10,110	10,250	19,010	14,910	5,450	3,840	5,360	3,860	6,320	149,380
Avg	21,388	16,804	18,125	16,399	18,671	29,587	37,912	25,744	9,704	3,879	4,485	8,950	211,647
Min	2,710	4,300	5,070	4,010	9,690	17,380	14,910	5,450	2,040	910	1,390	750	132,790
Max	75,840	52,110	40,950	42,600	32,190	48,540	75,310	57,670	31,160	9,150	13,120	23,890	336,230

Table 34. Keechelus Reservoir Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	30,770	55,880	13,110	30,980	13,750	25,240	19,160	24,570	6,900	900	1,620	13,690	236,570
1982	11,550	13,480	23,320	39,850	20,800	17,540	53,290	48,320	17,400	7,280	8,020	11,780	272,630
1983	13,780	23,360	31,310	14,430	27,860	23,590	38,320	22,320	15,640	4,660	7,880	4,930	228,080
1984	30,460	9,610	48,950	12,200	21,630	18,620	43,610	42,760	17,610	5,000	5,250	10,480	266,180
1985	16,190	11,000	6,070	6,420	11,000	42,370	54,490	39,280	9,050	3,070	5,720	27,090	231,750
1986	29,390	5,160	9,910	24,920	32,540	23,920	38,290	18,290	7,060	2,700	4,480	6,980	203,640
1987	38,010	8,860	6,390	7,480	24,910	41,600	42,700	13,620	5,050	4,820	2,500	2,240	198,180
1988	3,840	13,910	7,150	15,690	22,100	44,140	45,720	22,400	10,040	5,340	3,380	17,820	211,530
1989	25,670	22,500	23,180	9,290	11,690	47,410	42,620	26,990	8,930	6,090	3,780	3,810	231,960
1990	36,480	27,590	28,630	20,620	18,530	51,230	37,700	39,990	8,770	3,220	3,350	27,040	303,150
1991	86,470	18,370	23,130	37,920	13,170	33,460	39,760	25,230	8,550	4,350	2,940	2,980	296,330
1992	24,150	29,520	23,600	18,580	24,530	26,100	19,400	7,450	4,470	3,190	9,010	5,890	195,890
1993	18,320	10,620	15,100	7,250	22,330	32,490	46,400	19,420	8,510	3,250	2,160	3,910	189,760
1994	6,430	11,800	18,760	7,490	22,280	38,630	28,890	15,500	6,380	6,100	3,020	12,850	178,130
1995	19,880	25,100	13,130	39,440	20,920	24,690	45,530	19,460	7,950	5,440	2,910	26,590	251,040
1996	84,990	25,970	36,470	45,800	18,580	39,520	32,040	18,940	6,560	3,710	6,110	18,540	337,230
1997	25,010	13,770	23,900	21,600	32,840	38,730	81,850	56,920	25,480	7,550	7,970	29,160	364,780
1998	18,490	12,870	14,520	11,020	19,880	27,760	45,150	20,810	6,720	5,170	2,640	4,730	189,760
1999	30,090	32,010	29,380	10,900	12,100	24,540	51,080	65,440	36,020	14,820	3,630	8,280	318,290
2000	35,930	41,390	9,750	7,350	10,550	39,940	48,430	37,850	14,690	8,280	7,470	12,200	273,830
2001	6,970	4,760	7,590	5,380	15,640	26,510	42,800	19,460	8,720	5,350	2,470	16,150	161,800
2002	29,440	15,990	24,170	12,450	13,800	37,820	53,440	58,340	18,470	6,280	3,050	2,310	275,560
2003	8,940	8,200	28,230	19,460	29,310	26,930	34,270	20,590	8,700	3,140	2,470	19,440	209,680
2004	30,250	11,400	14,760	10,100	22,100	34,210	34,610	20,930	7,320	10,280	14,630	12,140	222,730
2005	23,370	27,550	30,890	9,810	10,900	24,440	19,590	9,270	6,190	5,110	3,860	10,130	181,110
Avg	27,395	19,227	20,456	17,857	19,750	32,457	41,566	28,566	11,247	5,404	4,813	12,446	241,184
Min	3,840	4,760	6,070	5,380	10,550	17,540	19,160	7,450	4,470	900	1,620	2,240	161,800
Max	86,470	55,880	48,950	45,800	32,840	51,230	81,850	65,440	36,020	14,820	14,630	29,160	364,780

Table 35. Inflow Volumes between Yakima River at Kiona gage and Yakima River at Prosser gage (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	18,870	24,950	22,040	20,670	17,060	7,870	9,650	17,630	14,810	11,480	16,480	20,630	202,140
1982	6,270	14,960	12,840	10,650	25,560	43,820	59,170	40,230	18,300	13,980	21,660	21,890	289,330
1983	15,960	20,460	18,320	20,140	18,020	39,630	25,580	12,470	21,420	18,260	17,170	14,260	241,690
1984	9,280	1,600	11,550	37,370	27,080	23,490	19,940	25,050	14,320	10,020	16,190	18,340	214,230
1985	9,520	5,360	1,970	6,980	11,500	17,220	12,270	12,160	7,110	17,150	22,730	14,830	138,800
1986	13,020	16,340	12,840	13,690	19,050	9,680	13,780	6,340	14,230	13,140	24,260	11,990	168,360
1987	8,300	14,120	15,070	16,520	11,370	17,460	17,240	12,130	13,620	13,180	10,550	7,210	156,770
1988	8,390	28,200	13,380	12,770	17,210	26,150	20,810	22,150	14,350	12,320	20,100	14,610	210,440
1989	19,150	9,390	11,260	8,420	13,650	23,360	13,490	8,400	9,070	14,680	14,070	15,130	160,070
1990	17,450	20,860	1,650	2,350	1,410	15,120	7,300	18,840	13,430	19,190	13,850	3,760	135,210
1991	3,380	4,130	7,470	11,830	17,550	15,990	10,200	1,570	3,010	3,460	6,050	2,420	87,060
1992	20,840	21,930	17,330	25,220	26,060	21,470	18,350	12,590	10,470	13,230	18,120	13,920	219,530
1993	9,560	8,890	8,020	12,970	17,260	18,910	15,640	11,830	12,630	12,200	13,140	16,230	157,280
1994	13,410	25,980	28,960	25,380	34,440	31,210	10,600	5,680	4,600	6,140	8,360	4,700	199,460
1995	18,890	23,550	22,310	26,350	35,280	46,940	30,170	23,650	12,860	16,980	19,020	15,560	291,560
1996	13,790	52,180	28,270	0	18,870	22,050	39,480	34,050	20,260	13,650	16,270	15,730	274,600
1997	9,080	15,770	14,880	16,280	8,900	370	5,230	36,970	24,800	20,110	27,020	23,240	202,650
1998	8,990	35,490	38,320	36,040	41,160	52,720	30,240	6,630	15,040	17,750	16,500	19,780	318,660
1999	15,680	12,630	13,510	16,910	10,790	24,150	18,660	890	13,950	18,770	14,170	15,710	175,820
2000	13,930	5,140	12,980	12,760	5,840	14,400	22,980	26,120	18,430	17,120	18,030	19,470	187,200
2001	11,050	14,800	14,630	14,340	18,520	11,130	13,710	7,230	2,430	8,850	13,620	9,780	140,090
2002	14,090	24,670	34,110	16,990	13,120	35,810	28,310	16,940	13,430	8,780	24,860	27,260	258,370
2003	12,360	13,560	35,830	30,280	32,520	24,390	19,210	19,290	9,160	36,890	40,130	41,360	314,980
2004	27,780	22,700	24,760	17,360	37,650	14,080	870	4,220	32,390	54,860	49,200	39,460	325,330
2005	14,660	13,070	17,290	14,200	7,360	11,720	19,340	8,850	12,950	16,420	30,410	17,790	184,060
Avg	13,348	18,029	17,584	17,059	19,489	22,766	19,289	15,676	13,883	16,344	19,678	17,002	210,148
Min	3,380	1,600	1,650	0	1,410	370	870	890	2,430	3,460	6,050	2,420	87,060
Max	27,780	52,180	38,320	37,370	41,160	52,720	59,170	40,230	32,390	54,860	49,200	41,360	325,330

Table 36. Inflow Volumes between Naches River at Naches gage and Naches River at Cliffdell and Tieton River at Tieton Dam gage (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	6,900	39,270	22,840	33,210	26,010	14,580	26,440	17,200	6,020	1,660	2,730	3,630	200,490
1982	5,040	8,530	9,490	42,060	24,110	28,500	73,100	65,230	19,780	5,510	5,030	3,370	289,750
1983	1,210	7,290	22,190	12,850	38,180	38,870	83,420	45,620	8,960	2,270	840	4,090	265,790
1984	2,750	6,510	41,250	16,970	27,640	26,350	26,200	43,950	17,530	3,150	1,000	2,510	215,810
1985	2,220	1,340	640	890	6,490	22,990	21,610	14,450	650	880	7,110	5,800	85,070
1986	11,270	5,100	7,350	27,130	50,380	33,350	45,990	26,990	3,210	130	2,440	3,710	217,050
1987	14,240	9,150	4,170	7,270	32,370	21,360	37,860	15,180	5,410	2,100	4,000	1,740	154,850
1988	730	7,390	2,930	10,990	15,940	31,490	30,070	14,430	6,280	30	3,680	3,120	127,080
1989	5,890	6,710	7,290	5,860	13,970	54,600	38,680	22,350	6,480	720	100	3,060	165,710
1990	2,100	2,440	8,880	9,460	15,930	45,970	15,490	33,580	11,900	4,640	13,950	5,260	169,600
1991	19,520	8,510	9,410	33,140	18,660	24,040	36,750	31,700	14,660	3,950	1,160	2,120	203,620
1992	3,990	5,630	6,240	14,680	16,040	14,560	18,910	8,050	1,930	60	3,370	3,040	96,500
1993	2,060	1,210	320	1,870	16,140	21,360	46,090	20,590	4,450	2,660	7,600	1,250	125,600
1994	0	460	5,410	2,780	11,830	26,740	21,560	11,900	2,310	670	830	5,030	89,520
1995	10,000	24,290	19,310	62,810	29,450	25,830	81,990	44,950	11,800	6,110	8,910	8,140	333,590
1996	14,850	17,710	31,120	104,540	40,250	54,040	47,740	33,660	14,480	3,210	4,140	4,500	370,240
1997	8,380	14,470	38,500	34,060	62,060	71,740	120,600	57,610	21,250	3,750	6,440	14,590	453,450
1998	21,400	7,860	5,000	12,290	27,880	49,660	80,340	32,190	4,250	540	6,830	10,330	258,570
1999	9,620	23,410	33,310	14,180	30,350	59,720	94,060	126,510	65,750	13,470	290	3,180	473,850
2000	19,320	20,210	9,090	11,890	15,790	55,960	38,730	29,220	10,420	3,130	10,450	5,790	230,000
2001	1,170	260	120	1,390	4,610	6,020	23,160	11,390	3,430	3,860	470	1,620	57,500
2002	8,060	9,050	23,690	13,720	15,340	35,050	41,830	52,430	7,750	2,080	2,210	3,840	215,050
2003	1,520	1,430	15,600	34,790	42,100	46,910	42,510	36,310	1,880	710	4,990	2,940	231,690
2004	3,830	5,280	7,210	10,750	24,090	39,610	51,830	33,290	10,180	5,730	13,920	11,630	217,350
2005	6,550	11,280	18,750	7,480	9,540	13,560	25,890	9,490	3,340	550	11,100	7,470	125,000
Avg	7,305	9,792	14,004	21,082	24,606	34,514	46,834	33,531	10,564	2,863	4,944	4,870	214,909
Min	0	260	120	890	4,610	6,020	15,490	8,050	650	30	100	1,250	57,500
Max	21,400	39,270	41,250	104,540	62,060	71,740	120,600	126,510	65,750	13,470	13,950	14,590	473,850

Table 37. Inflow Volumes between Yakima River at Parker gage and Naches River at Naches and Yakima River at Umtanum gage excluding Ahtanum Creek (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	3,830	48,690	43,800	35,340	26,920	29,850	24,880	15,560	5,850	1,370	9,830	28,710	274,630
1982	23,880	19,530	59,440	81,530	37,170	32,940	59,590	8,690	17,270	11,730	21,080	19,000	391,850
1983	14,950	10,140	15,180	18,420	56,720	24,930	13,470	22,900	25,040	22,490	24,410	22,450	271,100
1984	36,390	29,730	34,670	34,800	31,620	40,280	37,270	38,210	15,650	18,910	23,810	22,100	363,440
1985	15,950	14,990	15,590	18,050	30,340	25,180	11,130	3,170	7,230	15,970	21,500	19,950	199,050
1986	9,010	18,220	14,280	28,540	43,530	19,270	26,720	14,020	12,440	9,100	17,500	20,880	233,510
1987	14,510	14,030	4,500	9,380	19,430	28,920	13,950	13,280	16,870	15,520	11,670	9,710	171,770
1988	11,750	12,900	10,020	11,390	18,770	30,670	26,560	23,780	19,320	22,700	9,540	16,100	213,500
1989	13,190	15,470	10,880	5,540	23,670	37,290	15,320	11,580	15,370	17,110	17,640	19,360	202,420
1990	6,940	16,780	13,390	10,880	15,250	9,200	17,830	17,680	9,400	15,080	6,440	9,920	148,790
1991	19,050	29,270	24,260	25,510	19,550	18,840	20,490	23,240	15,080	25,530	20,200	12,010	253,030
1992	10,310	12,480	13,140	3,950	18,760	14,340	7,720	8,100	8,130	8,670	18,350	10,890	134,840
1993	7,300	6,230	8,120	9,940	22,400	21,740	6,950	6,720	8,420	11,040	6,580	7,920	123,360
1994	11,470	8,980	3,910	4,870	2,380	5,910	8,450	6,780	1,760	2,970	10,360	7,080	74,920
1995	3,440	1,450	12,610	58,320	48,870	41,080	30,080	22,620	21,460	24,610	28,850	23,610	317,000
1996	55,080	24,820	58,420	70,800	30,480	25,660	23,780	9,850	3,900	11,880	24,160	24,360	363,190
1997	14,520	6,830	22,000	27,190	53,840	81,590	105,580	58,750	19,820	26,540	28,740	30,920	476,320
1998	8,720	8,340	9,430	39,310	57,550	34,550	50,700	15,560	20,000	21,200	17,980	25,750	309,090
1999	9,300	8,440	21,200	18,130	26,990	23,250	17,520	24,400	6,890	23,010	24,620	34,020	237,770
2000	10,470	30,200	6,480	2,760	17,510	47,930	28,100	25,490	17,130	15,890	11,990	15,780	229,730
2001	40	240	100	180	9,370	21,340	21,300	21,470	23,650	23,340	18,470	12,400	151,900
2002	14,390	15,910	21,310	11,120	19,780	54,070	38,160	25,380	3,010	1,470	3,460	4,440	212,500
2003	0	5,590	19,990	34,160	10,070	1,040	2,470	1,120	1,120	850	2,480	8,510	87,400
2004	3,230	9,870	3,610	6,720	9,170	4,990	0	1,390	2,120	4,290	6,780	5,960	58,130
2005	3,420	4,900	8,200	7,750	1,970	16,200	9,250	1,640	40	1,300	2,950	9,730	67,350
Avg	12,846	14,961	18,181	22,983	26,084	27,642	24,691	16,855	11,879	14,103	15,576	16,862	222,664
Min	0	240	100	180	1,970	1,040	0	1,120	40	850	2,480	4,440	58,130
Max	55,080	48,690	59,440	81,530	57,550	81,590	105,580	58,750	25,040	26,540	28,850	34,020	476,320

Table 38. Rimrock Reservoir Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	22,260	71,690	32,590	39,820	25,720	27,990	42,820	37,030	23,090	15,340	14,570	16,160	369,080
1982	14,120	21,060	21,730	52,670	31,920	27,480	69,910	95,020	46,600	21,350	16,000	16,480	434,340
1983	14,560	24,680	36,780	24,130	41,330	35,720	82,650	74,710	45,810	27,110	19,920	12,190	439,590
1984	26,420	14,960	49,710	25,530	29,910	25,710	49,450	72,780	48,650	25,340	21,250	14,060	403,770
1985	15,770	13,530	11,060	9,530	13,030	36,280	59,830	67,360	26,840	14,580	13,960	14,000	295,770
1986	17,510	10,110	14,150	31,120	49,670	34,270	50,780	50,010	21,870	15,940	11,300	10,120	316,850
1987	21,020	12,760	11,300	13,610	32,990	39,710	62,830	32,110	18,630	12,780	7,730	7,190	272,660
1988	9,820	17,750	9,240	14,480	21,890	46,160	58,970	45,570	25,540	15,770	12,090	12,480	289,760
1989	20,000	18,280	15,370	11,680	19,110	50,510	55,210	56,030	26,750	18,160	17,450	11,030	319,580
1990	19,340	28,190	33,240	17,390	21,860	56,750	47,720	58,490	32,270	18,360	15,510	20,250	369,370
1991	47,710	23,920	25,030	41,260	24,290	29,870	44,780	50,900	40,390	21,680	18,650	12,630	381,110
1992	20,550	19,760	17,570	22,960	28,290	36,800	43,730	25,340	15,510	10,650	9,970	9,960	261,090
1993	11,800	9,620	9,630	9,200	19,140	27,570	66,800	36,300	19,820	13,940	9,470	11,480	244,770
1994	5,700	7,380	12,390	8,710	19,570	36,310	46,610	29,180	19,820	9,950	8,630	13,900	218,150
1995	16,250	27,390	21,230	60,790	37,900	29,190	76,180	61,140	39,330	15,930	12,160	22,450	419,940
1996	84,880	66,510	51,860	104,350	36,430	48,530	51,020	56,280	39,470	21,210	16,550	14,750	591,840
1997	17,760	19,940	43,360	27,260	40,400	55,380	110,900	94,020	58,770	30,250	27,150	38,950	564,140
1998	32,910	20,780	19,120	16,820	24,700	32,300	79,680	61,090	35,050	19,890	15,430	11,590	369,360
1999	18,770	31,810	34,080	17,000	21,260	30,880	61,100	98,680	68,570	35,510	27,250	20,170	465,080
2000	46,260	33,420	18,630	17,470	18,080	48,890	57,700	67,250	32,620	18,860	18,190	14,300	391,670
2001	8,760	9,250	9,510	8,450	12,300	18,370	43,870	27,280	18,820	11,960	12,480	10,360	191,410
2002	22,320	16,770	33,530	16,950	19,430	46,100	57,940	81,090	39,350	16,000	17,700	8,750	375,930
2003	10,020	12,120	31,030	35,540	34,630	35,930	51,070	56,260	26,470	13,890	14,890	14,540	336,390
2004	14,260	14,720	14,530	14,620	24,210	38,670	59,690	48,900	25,820	19,640	15,720	14,750	305,530
2005	15,350	22,310	33,400	14,850	15,510	24,560	37,670	21,140	15,230	10,480	7,870	10,070	228,440
Avg	22,165	22,748	24,403	26,248	26,543	36,797	58,756	56,158	32,444	18,183	15,276	14,504	354,225
Min	5,700	7,380	9,240	8,450	12,300	18,370	37,670	21,140	15,230	9,950	7,730	7,190	191,410
Max	84,880	71,690	51,860	104,350	49,670	56,750	110,900	98,680	68,570	35,510	27,250	38,950	591,840

Table 39. Inflow Volumes between Yakima River at Umtanum gage and Yakima River at Cle Elum gage (acre-feet)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	19,480	94,850	68,050	85,100	68,160	32,810	64,510	47,240	15,100	23,700	24,350	19,580	562,930
1982	9,320	15,710	45,280	100,930	96,950	82,010	108,540	94,010	35,420	19,470	24,980	16,270	648,890
1983	11,260	28,090	67,190	63,820	141,140	112,300	115,750	64,820	37,240	24,930	27,810	12,220	706,570
1984	19,670	9,230	102,850	67,820	91,360	78,410	87,660	72,510	22,130	7,130	29,420	22,400	610,590
1985	10,880	9,220	13,340	21,750	38,500	96,080	85,420	39,150	3,540	6,510	29,200	8,280	361,870
1986	6,460	8,120	17,110	51,820	128,370	75,760	62,220	30,720	12,710	5,750	28,560	2,410	430,010
1987	9,650	14,900	14,290	25,290	70,790	76,760	75,850	23,810	19,110	1,190	9,230	640	341,510
1988	3,990	17,380	12,930	26,810	36,810	93,400	70,740	51,820	20,820	14,350	24,950	4,960	378,960
1989	15,010	26,560	29,620	27,000	52,840	118,080	83,160	37,840	13,640	12,570	14,540	12,850	443,710
1990	8,790	23,260	28,600	34,890	66,240	129,920	94,170	50,840	35,840	34,200	22,820	21,640	551,210
1991	66,200	28,640	47,610	79,900	55,260	84,690	91,130	66,740	17,610	4,610	10,570	4,680	557,640
1992	11,630	24,870	20,590	44,200	74,100	56,710	60,270	34,210	28,550	25,260	10,430	5,030	395,850
1993	7,740	7,330	8,110	17,480	37,120	64,070	82,600	43,410	26,860	17,160	14,800	4,370	331,050
1994	1,780	11,970	22,160	14,790	32,360	69,870	61,770	41,440	12,380	13,550	17,690	8,770	308,530
1995	15,980	38,890	56,110	141,640	103,210	81,280	107,880	71,280	17,400	14,370	28,550	26,230	702,820
1996	60,330	105,940	107,050	281,100	129,260	150,590	124,680	74,170	40,560	41,990	28,720	9,420	1,153,810
1997	11,660	21,230	65,270	80,670	122,270	150,660	180,220	89,580	25,210	25,230	27,170	33,100	832,270
1998	23,620	10,090	17,750	54,590	79,050	90,740	121,530	45,670	31,580	16,110	6,180	11,750	508,660
1999	10,370	36,540	58,030	54,250	84,320	110,160	147,250	106,310	48,370	35,290	28,930	11,800	731,620
2000	19,210	22,940	22,970	20,700	57,170	123,470	88,510	50,970	7,780	11,200	35,560	12,780	473,260
2001	2,090	7,390	12,360	11,940	27,940	34,510	50,010	27,780	2,240	20,440	8,740	3,680	209,120
2002	21,220	24,810	38,760	31,890	47,760	95,580	113,520	72,140	15,100	5,770	37,640	19,520	523,710
2003	7,380	19,840	43,580	61,780	90,160	100,100	97,540	49,920	14,670	23,310	22,580	16,530	547,390
2004	22,560	21,810	19,980	36,810	81,210	80,760	79,760	26,640	15,260	27,660	20,500	16,540	449,490
2005	10,940	23,510	35,780	26,080	22,460	37,370	55,180	15,070	12,150	24,120	15,680	3,680	282,020
Avg	16,289	26,125	39,015	58,522	73,392	89,044	92,395	53,124	21,251	18,235	21,984	12,365	521,740
Min	1,780	7,330	8,110	11,940	22,460	32,810	50,010	15,070	2,240	1,190	6,180	640	209,120
Max	66,200	105,940	107,050	281,100	141,140	150,660	180,220	106,310	48,370	41,990	37,640	33,100	1,153,810

Table 40. Inflow Volumes between Yakima River at Prosser gage and Yakima River at Parker gage (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	38,510	47,070	48,170	56,610	44,010	23,870	25,300	35,540	26,730	18,650	28,010	34,700	427,170
1982	21,830	43,390	26,370	77,870	79,320	59,060	6,460	28,070	58,850	33,650	37,770	39,800	512,440
1983	25,240	41,900	90,790	109,060	168,260	99,150	74,130	53,780	60,230	36,360	41,770	31,090	831,760
1984	20,500	34,170	46,390	7,190	38,810	55,450	45,980	33,020	28,340	26,080	31,300	33,120	400,350
1985	34,800	35,600	33,380	37,570	39,890	46,680	45,830	51,720	19,630	20,220	38,010	34,030	437,360
1986	22,290	17,780	49,860	64,510	79,530	77,970	48,730	33,710	36,200	18,440	42,840	42,120	533,980
1987	22,970	30,150	35,670	39,310	87,210	59,380	43,200	35,450	25,150	14,760	16,790	33,430	443,470
1988	25,840	31,030	43,830	42,380	39,680	36,050	36,190	37,750	13,920	5,690	13,000	17,640	343,000
1989	13,820	19,510	19,440	15,280	48,610	40,370	51,660	34,860	29,560	20,630	18,380	25,420	337,540
1990	25,470	17,050	46,620	25,590	47,290	34,710	63,320	38,310	26,910	29,700	33,330	38,810	427,110
1991	22,620	25,210	19,980	12,250	25,780	43,180	47,960	85,320	54,410	27,100	21,430	37,470	422,710
1992	23,860	24,200	26,870	33,790	37,680	46,320	26,970	17,340	15,270	5,770	10,430	28,400	296,900
1993	28,270	35,180	44,380	39,110	69,850	75,380	45,320	30,890	14,400	9,940	16,280	24,190	433,190
1994	21,600	25,180	26,010	23,090	45,580	31,160	23,520	8,700	150	0	50	21,190	226,230
1995	18,130	25,920	66,140	85,910	68,390	51,250	78,670	37,970	34,060	16,970	27,720	34,110	545,240
1996	15,410	24,950	15,870	111,380	73,660	53,550	21,100	26,460	28,100	29,440	33,650	25,470	459,040
1997	34,410	78,810	154,770	93,290	96,310	76,970	25,440	21,850	36,330	29,920	32,260	33,140	713,500
1998	35,670	9,500	27,910	58,670	58,620	55,700	55,950	68,360	34,050	21,040	20,700	21,750	467,920
1999	29,350	57,160	52,020	63,060	86,130	53,300	60,770	28,800	34,230	27,130	24,000	27,280	543,230
2000	20,100	6,840	34,730	53,030	72,350	60,460	43,840	28,770	27,780	20,970	30,650	28,920	428,440
2001	26,320	25,570	26,830	22,060	28,520	29,480	8,980	8,250	1,500	0	1,680	15,960	195,150
2002	13,980	21,690	32,090	28,200	48,740	25,070	27,090	8,950	18,180	6,030	8,390	15,050	253,460
2003	22,560	29,170	59,920	61,660	39,010	48,320	40,900	14,120	15,030	14,170	7,160	13,410	365,430
2004	20,230	21,130	29,140	39,160	39,910	45,700	37,390	28,670	8,160	21,990	26,220	28,840	346,540
2005	32,310	25,740	27,180	21,170	22,330	19,330	18,590	9,050	190	0	1,100	22,720	199,710
Avg	24,644	30,156	43,374	48,848	59,419	49,914	40,132	32,228	25,894	18,186	22,517	28,322	423,635
Min	13,820	6,840	15,870	7,190	22,330	19,330	6,460	8,250	150	0	50	13,410	195,150
Max	38,510	78,810	154,770	111,380	168,260	99,150	78,670	85,320	60,230	36,360	42,840	42,120	831,760

Table 41. Inflow Volumes between Yakima River at Cle Elum gage and Yakima River at Easton and Cle Elum River at Cle Elum Dam gage (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	7,460	32,820	20,420	36,220	14,750	29,470	35,120	10,000	20,730	17,690	7,850	4,150	236,680
1982	3,920	8,300	19,080	35,200	17,320	16,670	76,080	35,970	11,940	10,980	14,780	5,010	255,250
1983	3,960	7,320	33,580	13,940	26,490	16,290	41,780	34,330	5,330	4,580	10,540	2,730	200,870
1984	6,770	8,360	40,600	12,840	25,350	20,980	14,310	46,340	13,480	23,390	17,360	4,460	234,240
1985	6,050	8,340	4,280	5,060	11,110	33,030	33,400	28,380	9,880	13,760	7,350	5,830	166,470
1986	15,070	4,410	3,810	15,200	41,060	16,600	21,700	14,060	2,420	16,550	6,930	5,650	163,460
1987	11,360	5,420	4,650	5,690	16,620	19,120	18,410	8,500	100	10,730	6,810	3,530	110,940
1988	3,120	6,500	5,330	10,960	10,970	21,310	20,930	8,330	2,720	2,790	4,250	5,370	102,580
1989	11,800	9,630	17,190	13,200	13,950	21,380	24,400	14,910	770	8,640	8,130	5,960	149,960
1990	4,310	9,770	19,230	23,910	23,160	46,700	19,930	28,170	2,310	5,180	1,570	6,360	190,600
1991	29,200	29,780	18,700	23,180	5,070	13,150	13,150	11,180	11,730	14,400	7,460	9,930	186,930
1992	7,090	20,010	16,750	18,010	14,170	9,710	1,120	1,870	70	2,410	7,030	5,370	103,610
1993	5,890	8,320	11,150	8,550	15,440	22,540	25,020	12,510	5,370	17,920	9,190	5,100	147,000
1994	2,610	4,040	7,050	5,280	12,390	18,240	9,110	1,110	1,920	1,330	3,350	5,360	71,790
1995	11,630	14,350	4,990	24,770	23,780	23,830	29,930	1,220	4,970	6,410	4,680	8,410	158,970
1996	29,740	17,170	30,630	19,600	25,420	17,760	12,890	15,900	90	1,250	6,520	6,630	183,600
1997	8,490	9,030	26,710	38,410	49,120	72,780	53,630	38,250	12,150	4,660	15,550	8,380	337,160
1998	12,070	16,470	15,740	18,700	20,660	15,070	21,390	20,720	1,010	7,920	18,150	4,270	172,170
1999	8,850	11,170	26,080	310	12,090	15,870	18,190	12,130	4,040	20	6,620	5,890	121,260
2000	7,020	27,000	17,800	14,160	20,430	33,140	21,820	25,060	19,260	18,330	7,170	7,150	218,340
2001	8,530	5,240	4,710	4,650	12,440	16,970	23,750	10,540	3,970	1,200	6,000	5,510	103,510
2002	12,550	11,110	16,250	13,370	18,820	48,150	40,700	24,030	17,090	22,560	7,490	4,570	236,690
2003	4,530	4,480	13,670	31,220	29,100	23,670	27,330	16,280	7,410	7,800	12,110	4,850	182,450
2004	5,260	8,810	10,690	11,640	24,890	22,370	16,770	13,590	7,950	5,820	12,650	4,570	145,010
2005	7,730	12,220	20,560	8,480	6,330	15,340	16,940	18,900	4,330	80	12,620	4,360	127,890
Avg	9,400	12,003	16,386	16,502	19,637	24,406	25,512	18,091	6,842	9,056	8,886	5,576	172,297
Min	2,610	4,040	3,810	310	5,070	9,710	1,120	1,110	70	20	1,570	2,730	71,790
Max	29,740	32,820	40,600	38,410	49,120	72,780	76,080	46,340	20,730	23,390	18,150	9,930	337,160

Table 42. American River Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	10,400	30,810	15,960	15,950	10,400	11,760	22,070	17,300	6,570	2,840	2,250	4,810	151,120
1982	5,630	7,330	5,620	21,530	11,220	11,620	42,120	55,650	20,710	6,000	3,770	5,240	196,440
1983	5,710	10,270	12,390	7,300	17,420	16,830	52,710	50,980	24,350	8,020	4,460	3,220	213,660
1984	10,860	4,400	17,390	9,940	11,880	11,670	25,950	43,130	23,500	6,030	3,440	3,580	171,770
1985	3,890	2,970	2,230	2,090	3,960	16,770	32,510	31,900	7,230	3,140	2,440	4,800	113,930
1986	5,520	2,770	6,280	9,700	21,340	18,880	30,160	27,480	6,640	3,070	2,540	2,760	137,140
1987	10,900	6,480	4,570	5,930	16,770	23,740	47,580	22,120	6,780	3,090	2,050	1,740	151,750
1988	1,910	5,130	4,240	4,600	9,230	25,430	31,320	25,180	10,880	3,730	2,450	2,630	126,730
1989	7,150	6,920	4,980	3,450	6,060	23,240	30,540	30,180	9,310	3,640	2,320	2,300	130,090
1990	4,370	10,420	13,350	5,510	8,390	34,030	24,160	31,260	13,660	4,870	2,950	4,510	157,480
1991	15,700	9,840	8,710	23,220	10,220	17,740	26,090	26,250	17,590	5,550	3,230	2,280	166,420
1992	5,340	6,970	6,640	11,710	16,310	20,360	27,500	11,230	4,520	2,530	2,190	2,090	117,390
1993	3,320	2,400	2,470	2,490	7,210	12,190	41,830	20,800	7,490	3,440	2,200	2,130	107,970
1994	1,800	2,790	3,650	2,520	8,600	23,180	31,970	16,730	6,610	2,660	2,080	3,350	105,940
1995	4,670	15,180	9,530	30,690	19,800	15,640	45,820	35,160	15,750	5,920	2,890	5,730	206,780
1996	24,190	25,080	17,880	41,290	14,690	28,950	28,280	29,170	12,850	4,680	3,240	3,710	234,010
1997	5,480	6,290	13,440	8,590	15,020	25,510	65,660	61,110	29,890	8,130	6,170	13,380	258,670
1998	11,200	7,340	7,330	5,460	9,980	16,070	51,000	37,090	13,040	4,440	2,660	2,740	168,350
1999	7,960	11,630	13,730	6,300	8,050	14,520	37,000	68,580	52,400	21,080	5,910	4,640	251,800
2000	19,550	15,870	7,240	5,510	5,980	24,130	30,210	34,650	13,310	4,700	3,600	4,360	169,110
2001	2,980	2,440	2,530	2,140	4,840	8,680	24,970	14,250	6,000	3,160	2,140	2,280	76,410
2002	11,370	9,100	19,770	7,480	8,740	23,090	37,330	51,200	19,160	5,950	3,700	2,700	199,590
2003	3,240	4,040	11,360	14,320	15,180	19,100	31,370	36,740	9,610	3,470	2,390	5,460	156,280
2004	6,980	7,130	5,110	6,410	11,160	23,380	34,720	23,640	7,510	4,190	4,040	4,430	138,700
2005	5,030	9,490	16,110	6,660	5,800	14,790	23,050	9,480	4,720	2,450	1,940	2,550	102,070
Avg	7,806	8,924	9,300	10,432	11,130	19,252	35,037	32,450	14,003	5,071	3,082	3,897	160,384
Min	1,800	2,400	2,230	2,090	3,960	8,680	22,070	9,480	4,520	2,450	1,940	1,740	76,410
Max	24,190	30,810	19,770	41,290	21,340	34,030	65,660	68,580	52,400	21,080	6,170	13,380	258,670

Table 43. Ahtanum Creek Inflow Volumes (acre-feet)

Water year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	2,030	7,900	6,800	10,610	7,630	2,980	3,850	2,280	830	580	560	700	46,750
1982	1,320	2,860	5,910	14,530	11,790	8,000	13,360	16,000	5,000	1,160	1,860	2,120	83,910
1983	2,400	4,100	11,070	9,650	20,270	13,650	22,170	16,500	4,170	890	1,790	1,550	108,210
1984	3,160	2,850	7,920	7,180	8,670	7,280	8,580	12,090	2,890	920	1,260	1,510	64,310
1985	1,820	1,730	1,900	2,010	3,710	6,250	5,700	4,130	550	620	1,140	820	30,380
1986	810	1,330	2,110	8,380	16,000	8,530	6,860	4,620	940	670	1,150	1,090	52,490
1987	710	970	940	2,150	7,110	5,940	7,630	1,420	890	720	970	860	30,310
1988	970	2,350	1,790	3,520	3,570	7,740	7,590	4,330	1,020	750	840	1,100	35,570
1989	550	530	800	1,110	6,280	10,940	8,830	3,580	760	620	920	1,070	35,990
1990	620	600	2,190	1,810	3,060	7,630	4,080	3,760	660	880	1,040	1,010	27,340
1991	750	710	840	2,310	2,480	3,100	3,940	5,500	1,530	710	810	810	23,490
1992	790	990	1,090	1,930	4,780	3,810	2,490	730	620	750	1,170	750	19,900
1993	900	580	630	1,060	5,990	7,110	8,190	3,820	660	560	720	750	30,970
1994	580	840	950	870	1,320	3,360	2,910	1,210	510	630	690	810	14,680
1995	530	960	3,050	21,690	16,920	10,110	23,540	12,890	3,400	970	770	940	95,770
1996	3,080	11,160	11,620	32,470	16,120	14,710	11,600	8,240	1,620	1,160	1,210	830	113,820
1997	870	1,340	10,640	11,730	15,830	13,450	22,090	15,410	3,400	1,050	1,200	2,060	99,070
1998	3,280	2,470	2,630	8,350	10,140	9,390	20,710	9,150	1,800	1,260	950	1,140	71,270
1999	1,050	3,040	5,000	4,930	8,660	8,410	12,480	18,050	6,110	1,640	1,220	1,360	71,950
2000	2,680	3,360	2,670	3,550	7,020	12,260	8,550	5,450	1,210	540	870	1,890	50,050
2001	1,050	1,080	1,190	1,280	1,940	1,900	1,970	1,370	880	760	940	920	15,280
2002	1,610	1,530	3,080	2,660	4,300	7,510	8,060	7,560	1,250	1,470	1,670	1,830	42,530
2003	1,490	2,000	3,990	11,440	9,010	9,550	9,520	7,320	960	1,190	1,320	1,190	58,980
2004	1,600	1,420	1,500	2,010	6,910	6,320	7,560	3,470	1,190	1,390	1,490	1,610	36,470
2005	1,610	1,960	2,130	1,730	1,840	1,950	3,560	1,090	960	870	990	1,060	19,750
Avg	1,450	2,346	3,698	6,758	8,054	7,675	9,433	6,799	1,752	910	1,102	1,191	51,170
Min	530	530	630	870	1,320	1,900	1,970	730	510	540	560	700	14,680
Max	3,280	11,160	11,620	32,470	20,270	14,710	23,540	18,050	6,110	1,640	1,860	2,120	113,820

Table 44. Columbia River below Priest Rapids Dam Flow Volumes (acre-feet)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	5,148,690	7,279,140	9,417,520	7,343,600	6,539,700	5,912,130	9,072,390	14,239,330	11,581,480	8,711,400	5,011,240	5,381,950	95,638,570
1982	5,312,530	6,192,990	7,368,190	7,046,480	11,886,940	9,578,180	11,293,880	12,184,460	11,480,320	7,760,520	5,057,060	4,943,200	100,104,750
1983	5,953,190	5,603,700	7,061,550	8,165,950	12,406,600	9,683,300	10,371,560	8,568,590	8,667,170	7,822,210	4,782,340	4,478,480	93,564,640
1984	5,342,080	7,412,030	6,944,920	8,037,020	6,994,310	8,207,400	8,686,210	8,746,310	7,919,000	6,466,310	4,330,310	5,016,790	84,102,690
1985	4,728,000	6,293,150	9,109,280	8,082,640	6,961,190	5,766,340	8,385,910	6,453,420	4,900,760	4,103,800	3,996,890	5,491,440	74,272,820
1986	6,852,290	7,885,880	5,232,790	5,493,020	7,575,670	8,790,740	8,540,820	8,101,880	7,296,590	6,082,710	4,489,190	4,965,620	81,307,200
1987	5,821,680	6,438,540	7,834,310	5,492,630	5,022,940	5,751,270	9,540,490	7,082,970	5,353,580	5,293,480	4,795,240	5,938,110	74,365,240
1988	4,920,390	6,654,740	7,274,970	5,939,500	5,563,830	4,606,610	7,211,300	6,593,850	5,208,200	5,015,010	5,283,570	5,272,660	69,544,630
1989	6,144,590	8,059,430	7,909,480	6,181,680	4,760,130	5,553,320	9,726,940	6,890,380	4,594,710	4,121,850	4,222,010	5,079,670	73,244,190
1990	6,144,200	6,961,980	7,567,930	7,680,000	8,687,600	8,492,620	9,092,230	13,033,380	9,316,360	7,036,560	4,404,890	4,888,060	93,305,810
1991	7,211,700	9,413,550	9,318,340	8,124,290	10,321,980	10,405,280	11,317,680	11,323,630	9,982,800	8,556,690	5,021,950	5,677,090	106,674,980
1992	5,933,750	6,047,000	6,850,110	5,048,530	6,466,710	5,609,450	8,376,390	8,815,930	5,687,200	5,533,480	4,586,380	4,415,600	73,370,530
1993	5,179,440	7,084,560	6,721,580	5,234,580	3,752,920	3,446,280	8,911,140	6,808,260	6,743,600	4,952,530	4,440,000	4,317,020	67,591,910
1994	5,318,080	5,344,460	5,170,510	6,253,880	5,367,070	5,356,360	7,465,380	9,010,900	6,567,670	4,782,150	3,573,420	4,352,720	68,562,600
1995	4,917,820	5,622,940	5,992,460	5,973,220	6,399,860	5,911,530	8,217,710	9,100,360	7,918,010	6,113,250	4,288,860	5,477,950	75,933,970
1996	6,529,380	10,070,080	10,355,700	11,217,510	11,071,730	11,252,230	13,021,480	14,112,390	11,397,020	8,737,190	5,823,070	6,029,550	119,617,330
1997	6,052,160	7,440,190	9,262,210	8,528,920	8,758,610	10,343,800	16,704,780	19,194,040	12,085,280	9,028,760	6,473,250	7,275,570	121,147,570
1998	6,248,530	8,471,000	7,182,740	7,846,610	7,315,040	5,004,490	10,532,230	10,234,710	8,105,850	6,739,830	4,805,550	4,439,600	86,926,180
1999	4,891,040	6,387,170	8,570,770	8,075,500	8,459,300	8,520,000	9,959,000	11,375,200	11,309,750	9,931,230	6,642,050	5,806,010	99,927,020
2000	6,795,760	9,363,960	9,237,020	6,996,490	6,512,330	9,254,470	10,072,060	7,946,970	7,731,570	6,857,850	5,129,450	4,749,620	90,647,550
2001	5,845,680	6,771,570	6,162,640	5,134,210	4,768,660	3,999,270	3,802,310	5,356,960	3,482,970	4,406,480	3,910,410	3,847,540	57,488,700
2002	4,579,630	5,343,270	6,209,850	5,606,280	4,526,080	7,301,950	8,854,210	13,100,820	11,164,950	6,675,960	4,513,980	5,052,890	82,929,870
2003	5,942,870	5,964,490	4,968,790	4,102,410	5,393,050	6,738,640	8,499,760	8,742,740	6,793,980	6,014,480	4,015,930	5,066,180	72,243,320
2004	5,809,580	6,884,430	6,259,240	4,939,830	4,718,080	5,664,390	7,637,950	8,211,570	6,410,380	5,898,240	4,711,730	5,210,970	72,356,390
2005	5,589,420	7,313,450	6,724,960	6,098,770	6,002,380	5,269,680	7,868,230	7,894,810	8,414,280	6,581,750	4,160,330	5,134,810	77,052,870
Avg	5,728,499	7,052,148	7,388,314	6,745,742	7,049,308	7,056,789	9,326,482	9,724,954	8,004,539	6,528,949	4,738,764	5,132,364	84,476,853
Min	4,579,630	5,343,270	4,968,790	4,102,410	3,752,920	3,446,280	3,802,310	5,356,960	3,482,970	4,103,800	3,573,420	3,847,540	57,488,700
Max	7,211,700	10,070,080	10,355,700	11,217,510	12,406,600	11,252,230	16,704,780	19,194,040	12,085,280	9,931,230	6,642,050	7,275,570	121,147,570